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In This Issue:

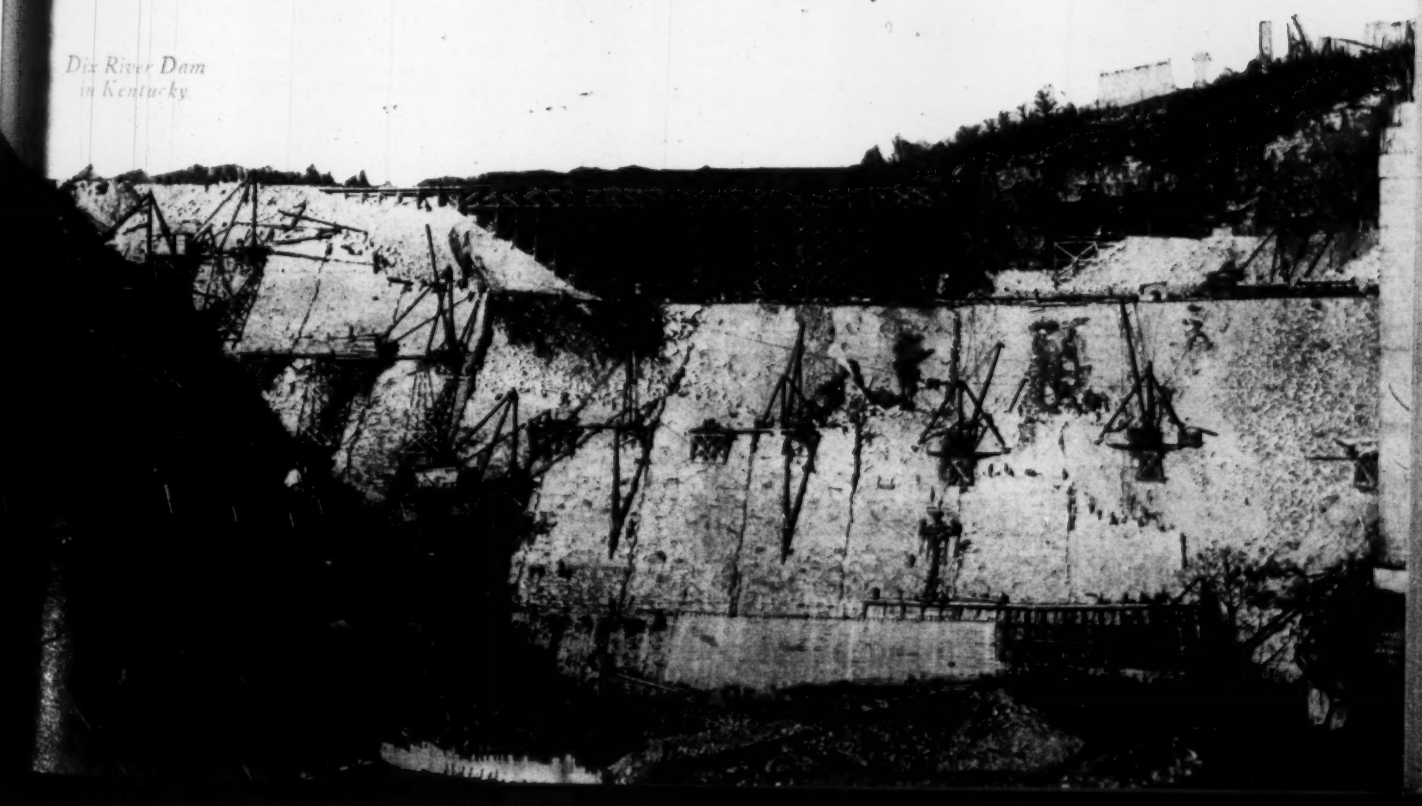
World's Largest Rock-Fill Dam
Built on the Dix River

Some Suggested Ways of Controlling
Mississippi River Floods

Long Spans of Smith Memorial Bridge
Erected by Cantilever Method

And

Engineering News-Record Statistics
of the Construction Industry



Dix River Dam in Kentucky

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FRANK C. WIGHT
Editor

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Another Sacrifice

MILTON H. FREEMAN, who took up the task of directing the construction of the Hudson River highway tunnel begun by Clifford M. Holland, has followed his predecessor in death. He, too, sacrificed his life to the work, watching over it with superconscientious devotion. The tunnel has taken heavy toll—Holland, Tallman and Freeman are gone. It repeats the story of the ages. Throughout time the building of great works for the use and convenience of man has claimed its victims. Not only gold and labor but also human life is wrought into what the builder creates—this is one of the tragic truths of man's existence. But there survives the record in stone and iron of what they accomplished who have gone before. Another record, more lasting and fruitful, is written in the memory of their colleagues.

Dix Dam Rock Fill

AS A design problem the Dix River dam described in this issue must await consideration until the ruling conditions and the development of the engineer's thought have been more precisely indicated. This however may be said, it is the first rock-fill dam of significance to be built in the East and it is the largest structure of its type ever completed. The article in this issue shows the structure and outlines the construction processes. Mainly the construction task was building a large rock embankment. Some two million yards of rock had to be excavated, hauled and deposited in fill. Ordinarily one thinks of rock-fill dam construction as primarily blasting rock into place from the high cliffs between which the dam will form a barrier. This was the way of building many of the early rock-fill dams of the far west. It was a very subordinate way of placing fill in constructing the Dix River dam. Not one-tenth of the rock was placed by direct blasting. The great volume required transportation—a railway haul of between two and three miles all the way either up or down a 2 per cent grade. Approximately 1,600,000 cu.yd. were hauled and placed in less than 14 months in five-car trains holding 80 cu.yd. Construction was then a problem in co-ordinated train movement and steam shovel excavation whose solution has seldom been surpassed in perfection in earth or rock handling operations. Let this fact be kept in mind in reading on another page the plain description of plant and methods.

Grassed Road Shoulders

METHODS of shoulder stabilization are getting increased consideration as the mileage of surfaced road increases. Almost always in the past the condition of the shoulders has been the least creditable feature of a road surface otherwise fairly praiseworthy. This is easily understandable. In the nature of things the shoulder is the weak element, particularly in paved roads. Built of the local soil, backfilled and not too well consolidated, it is readily eroded by wash from the pavement and rutted by the wheels which get off the paved track. Again, it is the natural inclination—with maintenance funds seldom as large as needed—to give preference in repairs to the paved surface, which represents the greater investment. Fundamentally, however, the road shoulder as commonly built is structurally weak and unstable. The measures now beginning to be undertaken, as indicated at the outset, are directed toward shoulder stabilization. One direction of effort is toward a stronger shoulder, of broken stone or gravel, treated perhaps with bitumen. California in the last year has done some notable work in replacing soft earth shoulders with broken stone in localities where local stone is handy and cheap. A more frequent method has been to increase shoulder stability by growing grass to cover and knit together the loose earth. Indiana this year will try shoulder planting on a large mileage of its state-maintained roads. While other states have successfully developed turfed shoulders in special localities, grassing road shoulders has not before been set down as a regular road maintenance activity. The results in Indiana will be watched with interest.

A Billion Gallon Water Project

OUTSTANDING features of the projected additional water-supply from the Colorado River, outlined elsewhere in this issue, are the volume, the pumping lift, the length of the aqueduct, the estimated cost and the infiltration gallery. As a whole and in nearly all of these particulars the Los Angeles project, which, it should be understood, is only in its preliminary stage, with no bonds for construction yet voted, outdoes everything of the kind in the world. Taken in natural sequence, we have first an infiltration gallery 15 miles long, designed to keep out the high suspended solids of the Colorado River. Then comes the 268-mile aqueduct with 1,416 ft. of actual elevation to be overcome for an ultimate supply put at almost a billion gallons a day. With such stupendous figures it is not surprising that the early cost estimates are $150,000,000 to $200,000,000. In its length of 328 miles the Coolgardie pipe line, Australia, exceeds the Los Angeles project, and in its lift of 1,313 ft. nearly equals it but the 30-in. diameter and 6-U.S. m.g.d. carrying capacity of the Australian project are tiny compared with the Californian. Another water-works project that ranks high in main and branch conduit length, although relatively low in other particulars, is the Apulian aqueduct in southern Italy (see *Engineering News-Record*, March 1, 1923, p. 389). This system comprises 152 miles of trunk and 841 miles of main and subsidiary branches and supplies 226 communities with a population of about 3,000,000. The first Los Angeles aqueduct, bringing in Owens River headwaters from the high Sierras,

does not fall far short of the proposed Colorado River aqueduct but its rated carrying capacity is only 260 m.g.d. In point of carrying capacity, the Catskill 500-m.g.d. aqueduct is the only near rival of the projected Colorado River aqueduct. In final cost the Catskill project, with the supplementary Schoharie Creek supply, exceeds the Los Angeles project, but what the actual cost of the latter may prove to be is a matter for conjecture. Moreover, the Colorado River aqueduct estimate seems to include no allowance for Los Angeles' share of Colorado River storage. Finally, seldom does one and the same engineer head two such epoch-making undertakings as has William Mulholland for Los Angeles and never before has one city been responsible for the inception and completion of so great a waterworks project and the inception of so much larger a similar project within the small compass of a quarter century.

Another Go at Muscle Shoals

TWO engineers, an ex-senator, a congressman and a Farm Federation Bureau man are going to advise the President what had better be done with Muscle Shoals. We do not envy the engineers their job. Both are well fitted to study the problem fairly and to judge it expertly, but they are the minority in a commission which will be dominated, numerically at least, by men whose primary instinct is political—politics of both party and of bloc—and men, too, who have long ago committed themselves to some particular form of treatment of the great plant on the Tennessee. If the two engineers are able to insinuate some sound sense and unprejudiced judgment into the deliberations of such a commission they will have indeed accomplished something.

Utilizing War-Time Terminals

TOWARD the end of the World War the United States started construction of several major army bases in strategic ports. These tremendous port terminals were not completed in time to be of military value, but their design was so novel and the location so commanding that there was the expectation that they would immediately be put into commercial service to the immense advantage of the ports wherein they were located. Most of the ports, and notably that of New York, where two of the new terminals were located, were sadly in need of some modern freight handling units. Seven years have passed since these terminals were completed, but little has been heard of them. Some of them, like the two largest and most elaborate at Brooklyn and Boston, have been held by the army as mere storage and shipping centers and have contributed little to commercial advance, and others have been put into limited commercial use which has not been distinguished by either success or failure. The one at Newark has been the football of local municipal politics for years, the city most of the time trying to bluff the federal government into giving away property that cost many millions. At last, however, the War Department has taken courage and has leased the property to a private company which announces that it is to devote the property to the purposes for which it has long seemed to be so admirably fitted, the transfer and storage of commodities made and used in the New York port district. Seven years is a long time to wait to prove the economies of the modern freight terminal in the congested port of New York, but the working out of the scheme will be worth watching.

A Contribution to Bridge Development

REASONS apart from its size give special rank to the new Hudson River bridge at Castleton, whose construction is recounted in the present issue and that of two weeks ago. The structure is the central feature of the most important bypass route built by any railway for a long time, and its service in this capacity promises to distinguish it among the structures of the Eastern trunk-line network. As its strategic position assures it a dense traffic of maximum trains, it will be subject to the test of growing railway loads perhaps more than any other railway bridge. With its heavy and efficiently worked-out construction, it thus constitutes an important contribution to railway bridge development.

Additional interest is due to the opposition which its builders had to overcome. Albany commercial interests fought its construction persistently, on narrow local grounds, and as their political influence gave them command of legislative as well as legal weapons they were able to induce the state authorities to oppose the enterprise by hostile laws. There were years of delay while the contest was being fought out in the courts. Its outcome marks a datum point in the definition of federal and state rights over stream-crossing control, establishing the supremacy of federal authority.

These several distinctions attract unusual attention to the engineering features of the bridge. In particular, the adoption of all-riveted construction emphasizes the favor shown this type in recent years. There is now a goodly number of riveted spans of 600 ft. and longer (if all forms be counted), and the drift toward the type continues. The resources of fabrication and erection have proved themselves able to deal with riveted construction in bridges of maximum size without undue difficulty or hazard. Whereas 20 or 30 years ago pin connection was almost necessarily used in long spans, the situation has been changed by the progress of the constructor's facilities and skill.

While the bridge was erected by the ingenious "progressive cantilever" method, for which of course a riveted bottom chord was essential, this was not the reason for the choice of riveted construction, as falsework erection was originally contemplated. Rigidity and maximum permanence were evidently the controlling objectives in the design.

If riveted bridges of long span show definite superiority in service, it can hardly be doubted that they will continue to grow in favor, to the point of rendering pin connection obsolete. But on this point of service value few tangible data exist, and it is much to be desired that specific experience records be brought together as soon as feasible to clear up the question.

In the meantime it may be said that the growth of riveted construction beyond the strictly short-span field has been slower than would be expected if the type were of proved superiority. Broadly speaking, the pin-connected type has held its place in the long-span field. With the present structure, however, strong support is given to the rigid type. It may prove to mark the turning point, and to establish riveted construction definitely

in the position of preference in the entire field of steel bridges.

In relation to the problem of railway live-loading, the newly opened bridge also possesses outstanding interest. Being located in maximum-traffic territory, and on a very busy line, it warranted an ample estimate of probable heaviest traffic loading for many decades. In this situation the designers settled on E70 train loading as their basis of proportioning. The associated working stresses, while somewhat higher than current practice in bridges of moderate span, yet may fairly be classed as conservative for a large structure. Thus the bridge affords a present margin of 15 or 20 percent in load capacity, and at least the same margin in allowable stress before an anxious point is reached. Its resulting reserve of strength assures its efficiency for a long time to come, unless revolutionary transportation developments should come to pass. Nothing now in sight contains any threat to the strength which it provides. Because of this fact, as well as because of its location and service, the new Hudson River bridge should in future years furnish a set of service experiences of determinative value to bridge design.

Customer Ownership in New Form

ON THE joint initiative of New Jersey and New York a remarkable experiment in public-works construction is about to be initiated. It may be regarded as a new form of the modern plan favored by the public utilities, customer ownership, though it has quite individual aspects. The two states are proceeding to build several bridges across Arthur Kill and the Hudson River by private financing, under a method which so far as we recall has no precedent. Indeed it is so novel that in its original form of purely private financing it was soon abandoned in favor of a modified form involving a certain amount of public financing.

The bridges are to be built by the Port of New York Authority, a quasi-municipal corporation created by the two states several years ago to improve the facilities for shipping at New York. They promise to attract sufficient traffic to be self-sustaining on a toll basis. This in itself is not uncommon, in fact it is always the case with soundly planned public works. The novelty is that advantage is to be taken of their revenue-producing capacity to finance them precisely like a private-corporation enterprise. The universal practice of building public works on either public money or public credit is expressly not to be followed; private capital is to be raised by the Port Authority, not on the security of public credit but on the security of the income earned or earnable by the bridges. This, the original plan, has been amended in one material respect by legislation just passed in the two states; public money has been appropriated to furnish an initial instalment of construction funds, and the declared intention of the legislatures is to repeat the appropriation for five years, furnishing ultimately one-fourth to one-half of the total cost, the remainder of the necessary moneys to be raised from private capital (but with the entire toll capacity as security for the private money).

Adoption of the new policy contrasts strangely with the fact that both states are at present engaged in similar interstate construction work on public money alone, money raised partly by appropriation from tax income and partly by bond issues—New Jersey in the Philadelphia bridge, New York and New Jersey jointly in the Holland Tunnel. Both undertakings are being carried out efficiently, and there is nothing in the history of either one to indicate a need for any change in financial system. Moreover, both are toll enterprises, whose income is to repay the construction costs. It can only be concluded, therefore, that the new plan is due to a wish to conserve public credit. In other words, the states apparently are seeking to combine the advantages of public and private financing.

There is the possibility, however, that the plan will prove to combine the defects rather than the advantages of the separate systems. But this point must be left for discussion at another time. For the present we desire merely to direct attention to the remarkable innovation which the two states have made, and to suggest that it is worthy of the reader's careful consideration for its possible bearing on future developments in public-works policies.

Road Grading Specifications

ROAD grading exhibits some curious practices. Ordinarily it is unclassified excavation. Besides earth moving it includes generally clearing and grubbing, tree removal, taking down hedges, fences, gate posts, steps and other obstructions. It includes scarifying and the shaping, trimming and finishing of shoulders, slopes, subgrade and ditches. Always, except rarely, it requires that a blanket price shall cover all operations. Never, except rarely, are other quantities given than total excavation. And in no two adjacent states are the requirements and items often alike. Ordinarily in practice grading discloses a profit less often than any other item of road building. All this has led contractors to talk of changes in grading specifications to bring about standardization, classification of excavation and, perhaps, quantitative itemization of the various operations as mentioned above which grading involves.

Truly on its face road grading practice seems to call for specification reform. But just what can be done? Road grading commonly, maybe indeed most often, is neither a yardage nor a classification proposition. It can be such where the line is on new location or where grade and curve reductions call for heavy cuts and fills. Then practice in quantities and classifications as the railways have worked it out would seem certainly applicable to road grading. But preparation of grade in the case of an old road is neither excavation nor earth moving in considerable volumes or for definite distances, it is a fussing task of half a score of small activities of which digging and moving earth is the major activity. Classification and statement of quantities are impracticable and not usable if they were practicable.

The road engineer in his specification practice then has not merely taken the easiest way. There was no other way open to him. Withal, however, there is much to criticise in road grading specifications and they call for exhaustive review. Some reforms in standardization and simplication are at least practicable and it may be that a critical study would show the way to reform in other respects. The effort is worth being made by road engineers because grading is about the most troublesome of the contractor's problems in pricing road work.

World's Largest Rock-Fill Dam Built on Dix River

Two Million Yards of Loose Rock Dam a Kentucky Gorge Three Hundred Feet Deep, Forming Reservoir 36 Miles Long and Holding 300,000 Acre-Feet

By George W. Howson
Resident Engineer, Dix River Dam, Burgin, Ky.

DUMPING almost two million yards of blasted rock into a gorge between two cliffs about 1,000 ft. apart and over 300 ft. high has been the major operation in building the Dix River dam in Kentucky. It is a rock-fill dam, a construction somewhat common in the far west, but little used east of the Rocky Mountains, and virtually unknown by example among eastern water-powers. Incidentally it is also the highest and largest rock-fill dam to be completed. To its crest it is 275 ft. above the gorge bottom and there are 1,747,000 cu.yd. of rock in its prism. All this rock had to be blasted from the cliffsides or from a cut in the plateau at the cliff top and then hauled and dumped into the fill between cliffs. Here, then, was the construction task—quantity blasting, hauling and dumping of rock. Facing and paving and power plant construction, all essential and important and sometimes unique, were subsidiary tasks of building.

Construction only is considered at this time. The structures to be built are indicated by the drawings of Figs. 1 and 2. There will be noted besides the dimensions, the topography and structure location, the varying face planes of the dam and the upstream face paving. Besides the dam and power plant, the structures are two bridges over the plant, a new water-works for Danville, Ky., and a 110-mile transmission line. It is, however, the dam and its direct appurtenances that are the chief construction interest.

Specifically the dam will be 1,020 ft. long, with a width at the crest of 20 ft. The upstream slope merges from 1 on 1.2 at the river bed to 1 on 1 at the crest. The downstream slope is 1 on 1.4. The dam is arched upstream on a compound curve of 10,250 ft. and 1,700

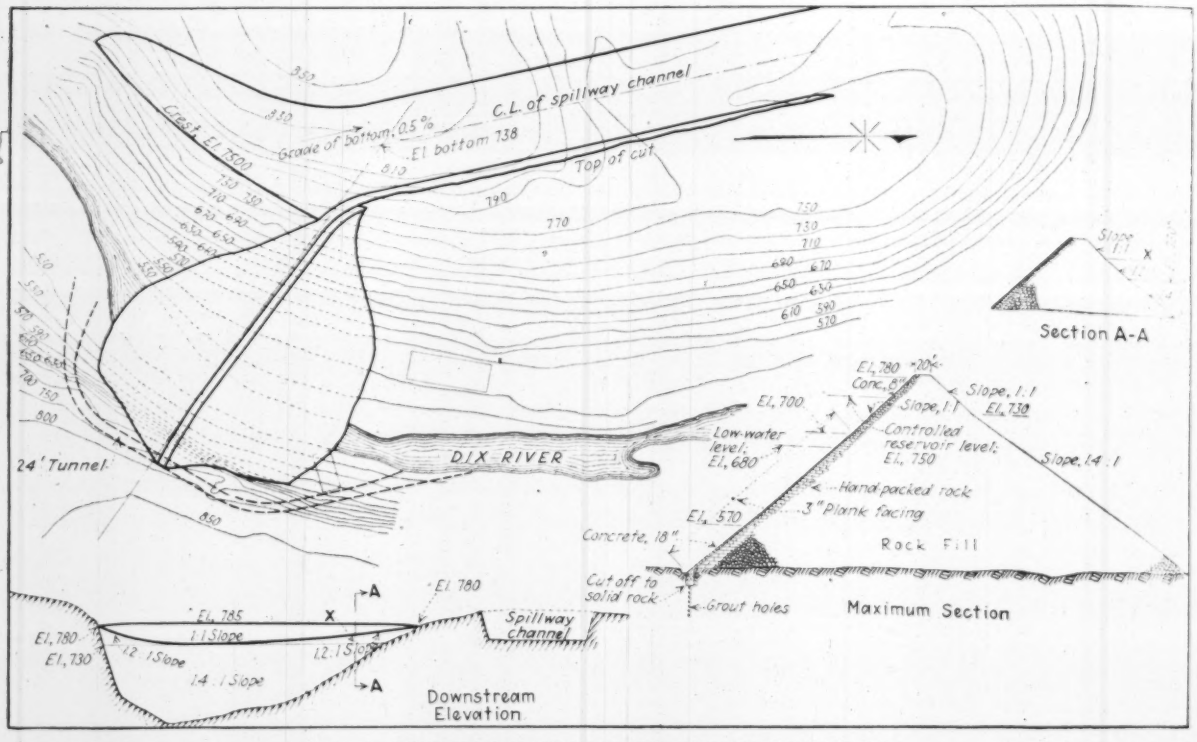


FIG. 1—DIX RIVER DAM SECTIONS AND LOCATION PLAN
Observe the contours indicating the deep narrow gorge blocked by the rock-fill excavated from the wide spillway channel.

ft. radii, with a maximum ordinate occurring over the river bed. The upstream slope of the loose fill supports a derrick-laid section of cyclopean dry-wall masonry, and a heavily reinforced-concrete apron overlies the derrick-laid face. This apron terminates in the river bed and in the canyon sides in a concrete cutoff wall carried into solid rock. Below the concrete cutoff, extensive drilling and grouting were carried on. The tunnel structure is amply explained by the drawings of Fig. 2. Note particularly that the main prism of the dam is loose rock fill—an embankment made by dumping blasted rock and letting it fall as it may and lie with no further attention except some slucing or soaking to promote settlement. In brief as affecting construction, the structures were not complex but the quantities were great.

Access and Work Plan—As the location was isolated, away from any road and some two miles from the nearest railway, the first operations were to construct

a truck road and then a 2-mile railway spur and to build a camp for up to a thousand or twelve hundred men. The camp site was the plateau on which is the spillway cut. Here were erected administration buildings, mess hall, steam power plant, shops, separate bunk-houses for white and colored workmen, a hospital, motion picture theater, etc.

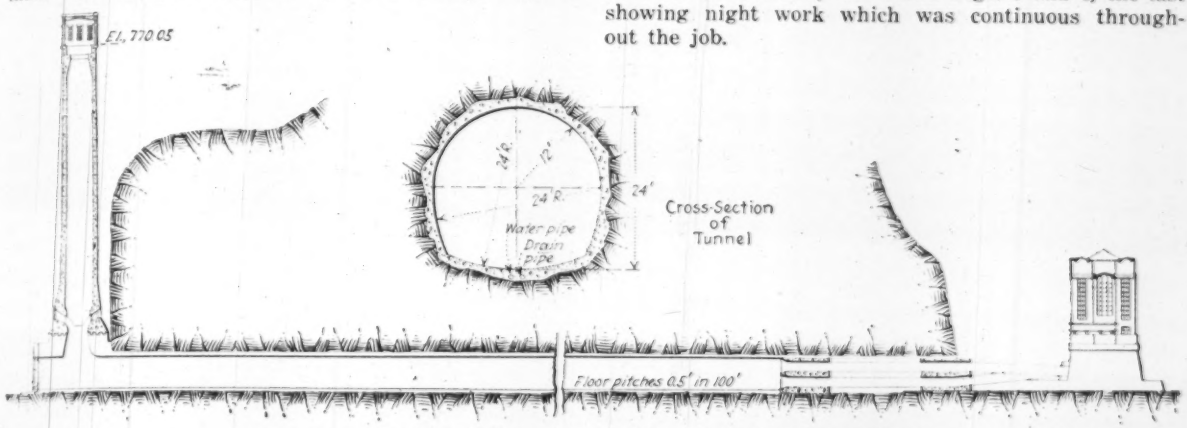


FIG. 2—INTAKE TOWER AND TUNNEL TO POWER HOUSE
This tunnel located as indicated on the plan, Fig. 1, served to carry the river flow during construction of dam.

The large-volume material requirement was rock for the fill. Except for some aid by direct blasting from the cliffsides it was the logical plan to go to the spillway cut for the work. This channel had to be excavated anyway and it was a simple process to widen out the cut if necessary beyond what was required for a safety overflow to get all the rock required. A railway was considered to be the logical plan of serving a long cut and of getting the rock without rehandling into the fill. This then was the plan, the details of which will be given: To blast the rock, load it with steam shovels and haul it by train to the fill. To build the hand-laid face and do the concrete work, the drill, steam shovel and train outfits were supplemented by cableways and derricks as shown by the views Figs. 3 and 4, the last showing night work which was continuous throughout the job.

Foundation Preparation—Before undertaking the fill there was a large task of clearing the rock fundation and getting in the cutoff wall. All dirt, clay and loose material were stripped down to bedrock, within the slopes of the dam. A narrow flood-plain of earth amounting to 95,700 cu.yd. had to be removed from the west side of the river, and 90,500 cu.yd. of talus material had to be excavated on the east side of the canyon, just below a vertical cliff. The former was done with two 78-ton, 3½-cu.yd. dippers, standard-gage shovels and 16-cu.yd., standard-gage air-dump cars, aided by two ¾-cu.yd. revolving shovels and 4-cu.yd., 36-in.-gage cars. The talus excavation was done by two ¾-cu.yd. and one 1½-cu.yd. revolving shovels, loading 4-cu.yd., 36-in.-gage cars. All the material was dumped outside the dam area, both upstream and downstream.

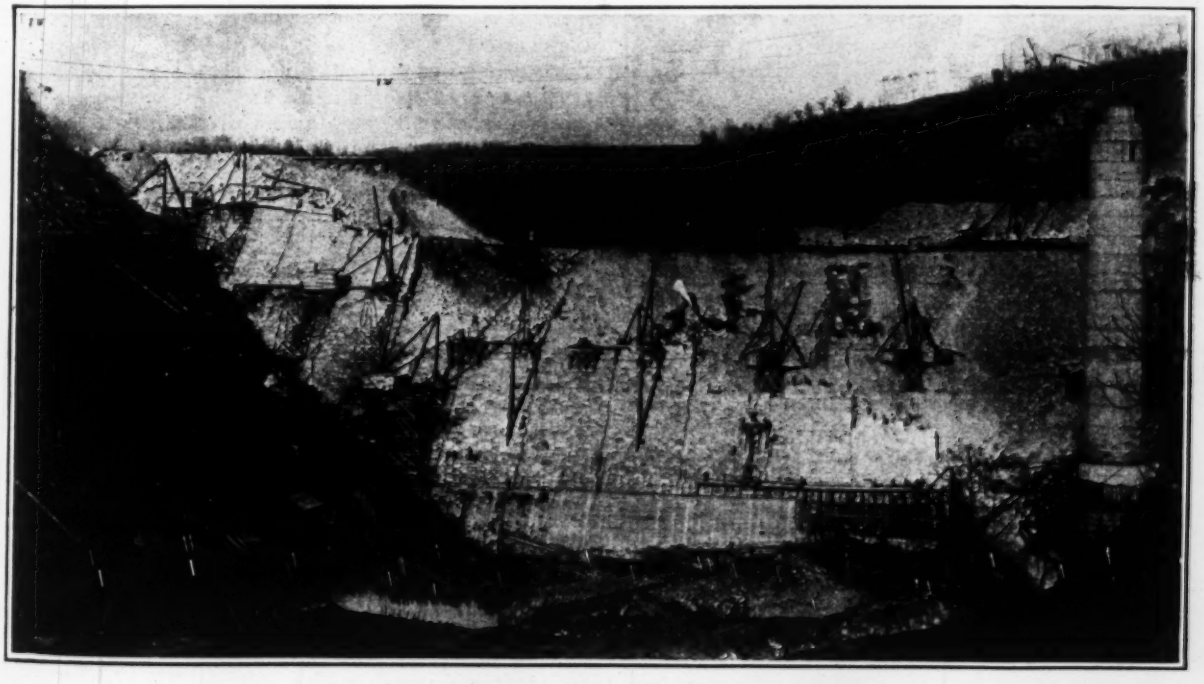


FIG. 3—CONSTRUCTION OPERATIONS IN FULL SWING
Rock fill is being made from trestle. Derricks are laying dry rubble paving on upstream face and the beginning of the concrete paving is indicated.

The cutoff trench was excavated to a depth of 25 to 30 ft. in rock. This work was carried across the river bed, in three sections, during low water season, by cofferdamming off the section upon which the work was being done. The rock excavation was done by power head drilling and light shooting to prevent unnecessary fracture of the rock on either side of the bottom of the trench. The excavated material was then loaded into skips and removed by derricks. In the final clean-up of the trench, all fractured rock was removed.

Preliminary exploration work was carried on in 1916 when diamond drill borings proved the foundation rock to be satisfactory. However, in order to safeguard against possible leakage, a comprehensive subsurface investigation was made along the line of the cutoff trench. Chilled-shot core drills were used for this work. The first series of exploration holes were spaced 40 ft. on centers, and drilled 250 ft. deep. Each hole when drilled was carefully tested with water, under pressure, and immediately thereafter grouted with cement grout. A second series of holes was then drilled midway between the first series. The individual depths of these holes were governed by the results of the tests of the first series. Similarly, a third and a fourth series was drilled, tested and grouted, where the foregoing tests seemed to require additional investigation. The total drilling was 18,500 lin.ft. of hole.

Main Dam Fill—Upon stripping a sufficient area of the foundation, the building of the fill began on the west canyon side while the stripping was being completed on the east side of the river. The original intention was to carry the fill up by 60-ft. lifts, and a switchback system from the spillway was laid out with this in view, for the purpose of transporting rock to

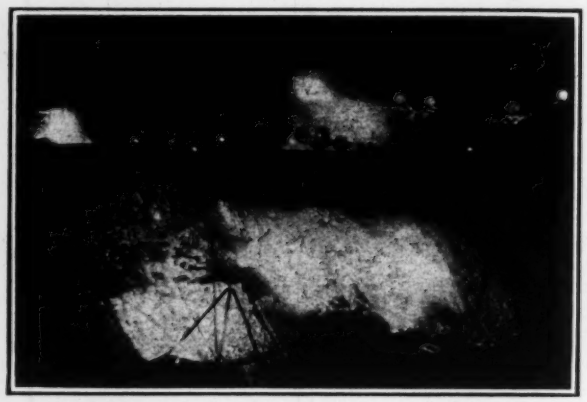


FIG. 4—WELL LIGHTED NIGHT WORK
Every operation was continuous day and night. Note the bright lighting of the slope paving work.

the dam. Grades of 2 per cent were adopted, with 1,500 ft. of track between switch points. The lowest 60-ft. lift was used only a short time, when it became apparent that the river would be closed by this lift before the completion of the diversion tunnel. The program was then changed, and the fill carried across on the 120-ft. level. This was done entirely by side-dumping on a semi-circular track, Fig. 5, which was shifted as the fill was built out.

The width of the fill at the higher levels would not permit a circular dump, so light timber trestles 60 ft. high were built, and a narrow fill carried across the canyon by dumping from these trestles. The dam was then widened to the theoretical slope lines by side-dumping and shifting track, Fig. 6, along the entire length of the original trestle. The timber of the trestles is a very small percentage of the loose fill and, consequently was left in place in the dam.

The excavation from the spillway channel was the main source of rock supply for the dam, and it was designed of such size that its yield of rock would nearly provide the amount of rock needed for the dam. A spillway width of 250 ft. at the bottom was adopted with a ¼:1 slope at the sides. The deepest cut is 107 ft. and the length is 2,300 ft. at the lower end of which the water cascades back into the river.

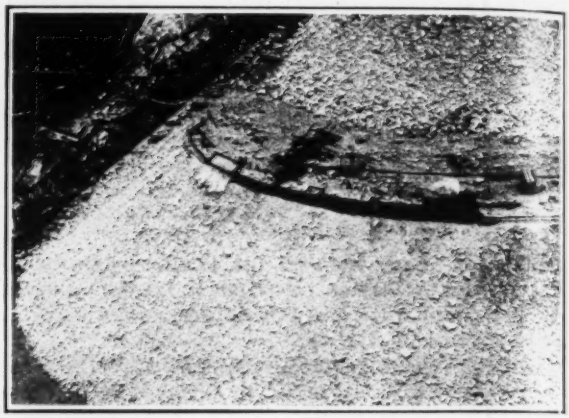


FIG. 5—CIRCULAR DUMP ON LOWER LIFT
First lift of fill built from west side across gorge by end dumping from a semi-circular track. This fill was 120 ft. high.

About 20 ft. back from the face, and 12 to 15 ft. on centers 6-in. holes were drilled with well rigs, then loaded and shot with dynamite, initially, and later with black powder. Three 78-ton, 3½-cu.yd., railroad type steam shovels, two of which were mounted on crawler traction, loaded the rock onto 16-cu.yd., standard-gage air dump cars. Eight 48-ton standard-gage locomotives were used to haul 5-car trains of this rock to the dam, via the switchback system. The movement of these trains was controlled by a block system, operated from a central tower, and more than 20,000 trains have passed successfully over this switchback system.

A secondary quarry for rock supply was opened on the east side of the river by two large blasts. This quarry, in the interest of progress, was used to supplement the spillway output. The first was a "coyote" blast, just downstream from the lower slope-line of the dam. This shot, using 82,000 lb. of railroad powder, brought down 88,300 cu.yd. of rock into the dam area. The second was a large well drill shot. Thirty holes, ranging in depth from 100 to 125 ft., were fired in one shot, and accounted for 70,900 cu.yd. of rock inside the slope-lines of the dam. After these two shots had been made, two 1½-yd. revolving shovels and 36-in. gage trains were put into this quarry for excavating the material left loose by the shots, and loading it for transportation to the dam.

Slope Paving—The function of the loose rock fill is to provide the required weight and a foundation for a course of derrick-laid dry-rubble wall, Fig. 7, which varies in thickness from 22 ft. at the bottom to 7 ft. at the top. This section was laid up of large selected rocks, varying in weight from 1 to 8 tons. The face rocks were laid true to line and all voids were tightly wedged and chinked, and the entire wall was carried back

against the loose fill section. This work was done by skilled Italian masons. Twelve stiff-leg derricks, mounted on the face of the dam, were in use handling the rock. Three-foot depressed grooves, Fig. 8, were left in the face of the wall, at 48-ft. intervals, to be filled with concrete forming the vertical concrete ribs under the expansion joints and 30-in. grooves were left

FIG. 6—DUMPING FROM TRESTLE AND WIDENING
Narrow trestle fill carried across the dam and then widened to slope lines by side dumping and shifting track.

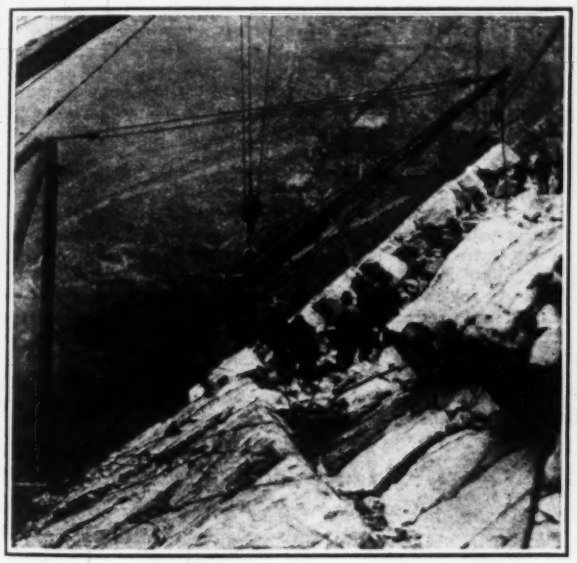


FIG. 8—GROOVES FOR CONCRETE PAVING RIBS
Grooves spaced 48x50 ft. filled with concrete which forms ribs under expansion joints of paving slab.

for the ribs under the horizontal expansion joints spaced 50 ft. apart vertically.

A reinforced-concrete apron, varying in minimum thickness from 18 in. at the cutoff trench to 8 in. at the crest, was laid over the surface of the derrick-laid wall. The concrete for this apron was mixed at a central mixing plant, located near the west abutment of the dam. From here it was transported in 1-cu.yd. bottom dump buckets by an inclined aerial cableway which delivered the buckets of concrete to the hoppers located on the face of the dam. From the hoppers the concrete was wheeled to the section of the apron being poured. The anchorages of the cableway were changed from time to time to accommodate the points of delivery as the concrete apron was carried up. The bucket was raised to the cableway carriage, into which it was automatically locked, and then moved by gravity down to an unlatching device, located above the hopper. At this point the carriage automatically released the bucket, allowing it to lower to the hopper where it was dumped. These cableways handled the material rapidly.

The vertical and horizontal ribs, previously mentioned, were poured first. Following this, the surface of each

FIG. 7—DERRICK PLACED SLOPE WALL
This slope wall gave smooth base for concrete slab which covers upstream dam face.

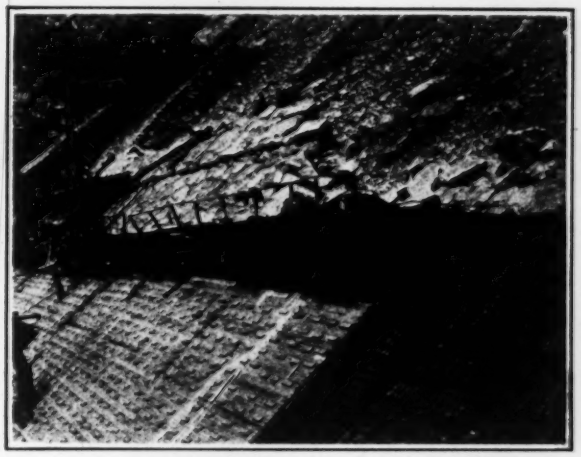


FIG. 9—PLACING THE PAVING SLAB
Wood forms used and left in place up to submergence level of dam.

panel of the derrick-laid wall between the ribs was cleaned and the reinforcing steel mat placed (Fig. 9).

The forms consisted of 3-in. tongued-and-grooved yellow pine planking, Fig. 9, bolted down to light channel irons, spaced 8 ft. apart. These channel irons were wired securely to the reinforcing mat, which in turn was wired to anchors embedded in the derrick-laid wall. Each panel constituted a continuous pour. In order to permit of inspection and thorough tamping, the formwork was carried up with the pour, never more than 30 in. above the concrete. A 1-in. cork board and copper seals were used in all expansion joints. Professor Abrams' theory of designing concrete was used on the concrete apron and all other concrete structures on the dam. Samples from the mixer and at the forms were taken at intervals and tested in the job laboratory.

Tower, Tunnel and Power House—A 24x24-ft. horseshoe-section, concrete-lined pressure tunnel 913 ft. long, Fig. 2, was driven through the east cliff, around the dam, to serve two purposes; first to divert the water during the construction of the dam, and second to convey the water to the penstocks and thence to the power house after the construction was completed. This tunnel was driven with an 8x12-ft. center pilot heading. The muck from the heading was loaded into mine cars. This section was then enlarged to full size and mucking carried on with a ¾-cu.yd., standard-gage tunnel shovel, operated by compressed air. The muck was handled by 36-in. gage 4-cu.yd. car trains. The pneumatic process was employed for the concrete lining of the tunnel.

At the intake end of this tunnel, a reinforced-concrete intake tower 260 ft. high and 22 ft. inside diameter, Figs. 2 and 3, was constructed. The shaft of this tower was carried up in 9-ft. lifts, one section being poured each day. A 17-ft. diameter balanced needle valve located about 60 ft. above the floor of the reservoir controls the flow to the tunnel. This valve is operated by an electric driven, oil pressure hoist, directly connected to the valve by a 4-ft. riveted steel pipe, which serves as a manhole to the tunnel. This hoist is located on the top of the tower.

During construction, the upstream end of the tunnel was left open for the diversion of the water. A 26-ft. hemispherical steel bulkhead, hinged at the top and erected in an open position was designed for the closure of the reservoir. This bulkhead was lowered into place, using two quadruple heavy duty blocks. The top block was attached to a heavy eyebar, anchored in the concrete at the top of the tower, and the lower block was attached through a bridle to a structural steel lowering frame, extending 25 ft. out from the actual bulkhead. An 8½x10-in. hoist engine, located across the canyon, controlled the lowering.

Three 8-ft. steel penstocks extend through a concrete plug inside the tunnel about 150 ft. from the downstream portal, conducting the water to the three hydraulic turbine units in the power house. The power is generated at 13,000 volts and is stepped up to transmission line voltage at an out-door substation.

Progress and Supervision—Work was begun in August, 1923, and the actual building of the loose rock fill was started in February, 1924. At the present time the work is rapidly nearing completion. In order to store the spring floods of 1925, great effort has been made to obtain maximum progress. All items of the work have been carried on continuously day and night.

The project is being carried out from plans and specifications prepared by L. F. Harza, consulting engineer, Chicago, whose principal assistants are F. A. Dale, and electrical engineer Erik Floor. G. T. Bogard, chief engineer for the Kentucky Hydro-Electric Co., designed and built the transmission lines. George W. Hamilton is vice-president of the Middle West Utilities Co. in charge of engineering, and Arthur P. Davis and M. M. O'Shaughnessy were consulting engineers on the design of the dam. The L. E. Meyers Co. of Chicago was the general contractor on the power development. C. E. Collins is vice-president and general manager of the L. E. Meyers Co. and A. L. Nelson is superintendent. The John F. Lusk Co. subcontracted the driving of the tunnel and D. D. DeLuca the laying of the face wall. The writer was resident engineer in immediate charge of work.

Railway Engineering Developments

Further Reports to the Annual Convention of the American Railway Engineering Association — Continued from p. 488

Paving Road Crossings

Committee on Signs, Fences and Crossings

BITUMINOUS crossings are still in the experimental stage but our knowledge is sufficiently advanced to warrant the adoption of the specification submitted. The use of wooden or metal flange guards is left optional, as some roads find them necessary and others seem to get better results when the wheels are allowed to roll their own flangeways. Climatic conditions, variations in construction methods and differences in highway travel may account for the varying results obtained.

Concrete plank crossings on the Chicago, Burlington & Quincy R.R. are giving good service and their maintenance cost has been very slight. But the railroad considers that while this is cheaper and more durable than wood plank for heavy traffic crossings, yet crushed rock with asphaltic binder is preferable and more economical. The latter construction gives good riding service and has the advantage that when repairs to track are necessary less labor is involved than is the case when concrete plank must be removed.

* * *

Filling Bridge Openings

Committee on Roadway

TO DETERMINE whether the replacement should be by filling the bridge opening or some other method, a careful analysis of all the component elements of cost must be made. In many cases, methods other than filling may be found preferable. Where a more permanent type of construction costs less than a renewal in kind, there can be no question as to the economy of making the improvement. Replacement or renewal of bridges and trestles takes place for one or more of the following reasons: Obsolescence, deterioration and accident.

The problem resolves itself into whether it is more economical to fill, renew in kind or to replace with a more permanent type of structure at a greater investment outlay. Care should be taken that the full life of the structure is obtained; for instance, a bridge that may last one or two years longer by an annual expenditure of an amount less than the annual interest and maintenance charges of new structure, should not be renewed or replaced until expiration of its full service life. The element of safety, including strength of structure and elimination of fire hazard, must be given consideration.

* * *

Cost Data and Statistics

Committee on Records and Accounts

COST-KEEPING and statistical records, as applied to railroad maintenance, are so closely related that one may not well be considered without the other. For example, the cost of renewing ties per unit for a certain period is arrived at by cost-keeping, but the result is a statistical record, and the records of the number of ties placed, their cost, and the labor cost of renewing furnish the information from which the cost is determined. Figures obtained from cost-keeping and records serve as a record of past performances, but become of greater value when proper application of them is made. Thus, to know the cost of renewing ties per tie is to establish a measuring stick for making comparisons of cost of future renewals with incentive to reduce the cost and establish a new measuring stick. To know the length of life of ties in track and their costs lays the foundation for the study of the economic renewal of ties.

Information must be comparable. Data should be in sufficient detail to make the comparison intelligent, but too much detail is confusing and should be avoided. The number of comparisons which should be made to permit a fair criticism should be sufficient to give a true picture of the situation. If the information is not used, its preparation is a waste of money and its compilation should be discontinued at once. It should be possible from good records to predict results, to locate a trouble definitely and to point out the possibility of further progress and improvement.

Dust Control on Gravel Roads in Michigan

Essential Where Traffic Exceeds 500 Vehicles—Asphaltic Oil, Calcium Chloride and Bituminous Surfacing Used

By B. C. Tiney
Maintenance Engineer, Michigan State Highway Department, Lansing, Mich.

Michigan, with over 10,000 miles of well-kept gravel roads, practices many proved methods of dust alleviation. In this paper prepared for the American Road Builders Association, Mr. Tiney tells of these methods in practical terms of effectiveness and cost.—Editor.

DUST control is desirable on roads carrying a daily traffic of 300 to 500 vehicles, and it has come to be regarded as almost a necessity for traffic of more than 500. The practice has been along two distinct lines: (1) The application of dust palliatives which afford a temporary reduction of dust; (2) the application of bituminous surface treatments which afford a complete elimination of dust.

Dust Palliatives—As dust palliatives, the two materials in use are calcium chloride and light asphaltic oil. The first essential to the successful use of either is that the surface of the road, prior to application, shall be covered with ½ to 1 in. of loose gravel uniformly distributed. This loose cover ranges in size up to ½ or ¾ in. and is floated back and forth daily by patrol graders or drags, keeping all depressions filled. The smooth-riding quality of the road, with or without dust palliatives, depends upon preserving this floating cover.

Any attempt to apply calcium chloride or light oil in sufficiently large quantities to eliminate all dust will result in the loose gravel solidifying under traffic. This forms a surface crust upon which the patrol graders have little or no effect, and which, under traffic, soon develops holes. It is then necessary to scarify the surface in order to restore its smoothness. However, if dust palliatives are applied more frequently but in smaller quantities per square yard, they may be made to reduce the dust to such a degree that it is not objectionable, and at the same time will not mat the surface or injure its riding qualities.

Calcium Chloride—Michigan uses calcium chloride conforming to the A. S. T. M. Specification D 98-22 T, which permits either the flake or granulated form in particles up to ¾ in. in size. It is delivered in airtight metal drums of 375 lb. each or in weatherproof sacks of 100 lb. each. The sacks are preferred for ease in handling, but if the material is to be stored for some time before application the drums are more satisfactory.

The quantities recommended for application on roads having ½ to 1 in. of loose gravel on the surface are: First application, 1 lb. per square yard; second application, ½ lb. per square yard. For fairly heavy traffic, a third application of ½ lb. per square yard is usually required. These applications are made at intervals of four to six weeks and the total of 2 lb. per square yard is generally ample for the season.

Local conditions sometimes warrant a variation from these quantities. A new road, not thoroughly bonded, will require a heavier application because much of the calcium chloride is absorbed into the body of the road where it aids in consolidating the gravel. Roads which have been treated for two or three years retain some of the effects of the previous treatments and in a number of such cases we have found that two or sometimes three applications of ½ lb. each are sufficient for a season's work. The effect of a treatment may be considerably lessened by a heavy rain, within a period of 10 hours after application, which tends to wash a great deal of the material to the sides of the road.

Calcium chloride not only reduces the dust but conserves the gravel on the road. Roads constructed from gravel with a sand filler are very difficult to hold intact under traffic in dry weather, and this is especially true if the road is built on a sandy subgrade. On these sections, calcium chloride is of particular benefit, not only as a dust palliative but as a bonding agent to prevent raveling of the metal.

The application requires no elaborate equipment. A supply of the material carried on a truck is fed into a lime drill coupled closely behind the truck or into a cheaply constructed wooden hopper attached to the rear of the truck-body. Such a unit of equipment is capable of covering from 5 to 10 miles of road per day.

The cost of calcium chloride, applied, is 2¾ to 3c. per square yard or about $300 per mile for a full season's treatment of 2 lb. per square yard. This cost is materially lessened in some sections of the state where, by reason of lighter traffic or other local causes, a total of 1 or 1½ lb. per square yard is sufficient. In some northern counties where the heavy traffic season is shorter, the application is made to a width of only 8 ft. This treatment is further distributed toward the edges of the road by patrol graders and traffic, and gives satisfactory service at a cost of about $125 per mile per year.

About 740 miles of trunk-line road were treated with calcium chloride in 1924, this being much less than was originally planned, due to a reduction in maintenance funds. With adequate appropriation of funds, we expect to triple this mileage in 1925.

Asphaltic Oil—Light asphaltic oil has been used to a somewhat limited extent as a dust palliative in Michigan during the past few years. Experimental work with oils of different densities led to the adoption in 1923 of the specification, given in the table herewith, which provides an oil of about 35 to 45 per cent asphaltic base:

SPECIFICATION FOR ASPHALTIC OIL FOR USE AS A DUST PALLIATIVE ON GRAVEL ROADS

(Cold Application)

The asphaltic oil shall be homogeneous, free from water, and shall meet the following requirements:

(a) Specific gravity, 25 deg./25 deg. C. (77 deg./77 deg. F.) not less than 900
(b) Flash point, not less than ..... 80 deg. C. (176 deg. F.)
(c) Specific viscosity (Engler, 50 cc. at 25 deg. C.) ..15 to 30
(d) Loss on heating at 163 deg. C. 20g. 5 hr. not over...30%
(e) Total bitumen, not less than 99.8%

The oil is applied, with a pressure distributor, to the road surface which has been prepared as previously described. The first application consists of ¼ gal. per square yard which is followed after an interval of about six weeks with a second application of ¼ gal. per square yard. These quantities are intended for roads having a floating cover of ½ to 1 in. of gravel. On such roads, the two applications have been found to reduce the dust quite satisfactorily for the season, without matting the surface. The average cost of this work is as follows:

Oil, delivered	$0.0675 per gallon
Application	0.0175 per gallon
Cost, applied	$0.085 per gallon

This gives a cost of $0.028 per square yard or about $300 per mile for a full season's treatment. A 20-mile section in the northern part of the state was rendered fairly dustless during the past season by one application to a width of 16 ft. at a cost of $160 per mile.

It has been demonstrated in the last year that light oil treatments can be made to compare favorably with calcium chloride treatments, both in cost and results obtained, provided careful attention is given to the details of the work. The state treated 83 miles of trunk-line gravel with oil in 1924 and plans to treat 109 miles in 1925. The use of this material is limited by the fact that many county organizations do not have the equipment or storage facilities necessary to handle it. Oil has been applied to gravel roads mainly in those sections of the state where the maintenance of macadam has provided equipment and experience.

Bituminous Surface Treatments—A further solution of the dust problem lies in the bituminous surface treatment of gravel roads. Practice is very similar to that involved in the surface treatment of waterbound macadam. These treatments cannot be successfully applied to all types of gravel roads and should be attempted mainly on those containing a high percentage of stone, thoroughly compacted. The nearer this approaches a macadam in structure, the better will be the results of the treatment. Full thickness of metal and proper drainage are important factors.

Preparation of Surface—As soon as the ground is free from frost in the spring, the road is shaped with a grader and, if necessary, scarified lightly to eliminate all ruts and

holes. Traffic is then allowed to compact the loose material, and a true cross-section is maintained by intensive patrol work for a period of a couple of weeks or until the time when weather conditions are suitable for applying the treatment. When treated, the surface should be fairly dry, but the main body of the gravel may contain considerable moisture. In fact, some of our best results have been obtained with treatments placed early in the season before the gravel had lost so much moisture that it began to disintegrate under traffic.

Immediately prior to treatment the surface is thoroughly swept with a rotary broom, removing all loose material and exposing the larger stones until they project slightly. Special attention should be given to cleaning thoroughly the edges of the metal, using hand brooms if necessary. It is the practice to apply the treatment one foot wider, on each side, than the originally constructed width of the gravel. If detours are available it is advisable to close the road to traffic from the time of sweeping until the completion of treatment, and, if convenient, for 48 hours after treatment to allow the bituminous material to obtain an initial hardening. The latter practice is recommended for the reason that it lessens the objection of the public to driving over a newly treated road.

Application of Treatment—Bituminous material is then applied by a pressure distributor of such type as to insure uniform application and proper control of quantities. The first application, or prime coat, is made at the rate of 0.2 gal. per square yard and allowed to penetrate for at least 24 hours before making the second application.

The second application is made at the rate of 0.3 gal. per square yard and is followed immediately with a covering of stone or slag chips or pea gravel at the rate of 12 to 18 lb. per square yard. Best results have been obtained using a covering material up to ½ in. in size with the dust removed. This is usually spread directly from a truck by opening the rear gate slightly, or by patented spreading devices attached to trucks.

The bituminous materials which have been used in this work have been mainly tars, although some treatments have been made with asphalt. The tars used conform to the A.S.T.M. Specifications D 104-23 T for high carbon tar and D 105-23 T for low carbon tar. Experience has led to no decided preference in the use of high or low carbon tar as equally good results have been obtained with both types. The asphalt used conforms to the Specification OC-2, published in Bulletin 691 of the Bureau of Public Roads. This is a very volatile material, having a flash point of not more than 122 deg. F.

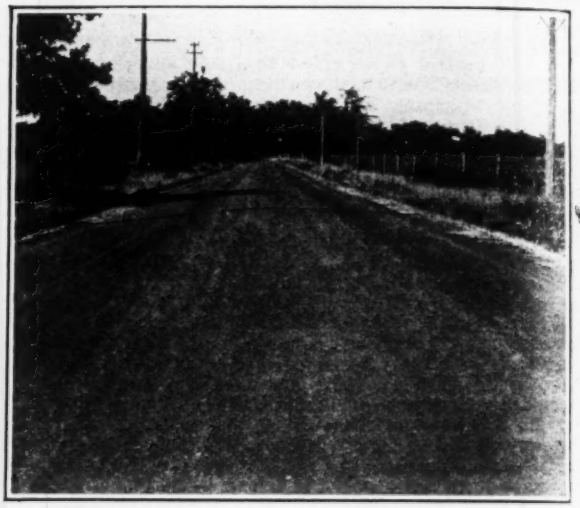
The above specifications for both tar and asphalt provide materials which may be applied without heating. It is an advantage in some cases, when applying them in cool weather, to heat the materials to about 115 deg. F. as they distribute more readily and uniformly.

Subsequent Hand-Patching—Patrol patching following the treatment is very necessary. Small breaks in the surface must be patched soon after their appearance. For this purpose, a mixture of coarse sand with the same bituminous material used in the surface treatment is employed. This mixture is made in the ratio of 14 to 17 gal. of bituminous material to 1 cu.yd. of sand. A lean mixture is desirable and the mix should be so adjusted as to give a complete coating of particles with no free bitumen. This work is best handled by using a small concrete mixer at a central yard and stocking the mixture in small piles on the road shoulders. One man with a wheelbarrow, broom and shovel can patrol 8 or 10 miles of road although it may occasionally be necessary to supplement his efforts with a gang and truck for a day. The surface breaks are filled with the mixture, which compacts readily under traffic.

If the first year's treatment is in fair condition the following spring, it is patched where necessary and given another treatment of about ¼ gal. per square yard. Subsequent treatments are generally made at the rate of ¼ gal. per square yard.

The necessity of treating every year depends upon the traffic and local conditions. Some sections have been given three treatments in five years and one section has had two treatments in four years. Average conditions would probably require three treatments in four years. In the northern part of the state where snow is not removed for wheel traffic throughout the winter, these treated surfaces are generally found to be in good condition in the spring, due to the fact that wheels with non-skid devices are not traveling on the bare surface when it is cold and brittle. In the southern part of the state this severe winter traffic together with excessive frost-heaving has broken up some sections to the extent that an entirely new treatment was necessary the second year. In such cases the unbroken portions of the old mat should be removed by scarifying at the time when the frost is leaving the ground. If they are left until later it is very difficult to scarify them. The old mat becomes thoroughly broken up under traffic and patrol graders and the surface is again treated in the same manner as in the first year.

The average cost of a first-year treatment is about $1,000 per mile with about $200 additional for patch work. Unless



SURFACE-TREATED GRAVEL ROAD NEAR ANN ARBOR, MICH.

it is found necessary to remove the old mat, the subsequent treatments will cost about $200 per mile less. On a basis of three treatments in four years the average cost is $850 per mile per year. This appears to be economical maintenance for roads carrying a daily traffic of 800 vehicles or more. Roads with a traffic of 800, which are maintained by the use of patrol graders, with the necessary resurfacing and dust palliatives, are costing an average of $600 to $700 per mile per year. On some of the heavier traffic roads the cost of this loose surface type of maintenance would equal or exceed that of the treated surface type.

We had 88 miles of surface-treated gravel on the trunkline system in 1924 and expect to increase this to 141 miles in 1925. There are, on the sections previously treated, 31 miles which we do not anticipate will need re-treating in 1925. We have attempted to select for treatment only those roads whose condition appeared favorable and which would be in immediate charge of superintendents who had had some experience in surface treatment work. The results have, in general, been satisfactory. These treatments convert the gravel road into a higher type surface and eliminate all dust. They are very popular with the driving public and are the occasion of much favorable comment.

Payment for Reconstruction Work in North France

Paris Correspondence

A project of Monsieur Dalbiez, the minister of the liberated regions of France, is expected to alleviate the situation which has become acute with respect to the payment for work done by contractors in rebuilding North France. Of the six billion francs which will be expended the coming year cash will form only 2,400,000,000 francs, the remainder being represented by ten-year government obligations, thirty-year annuities and payments in kind. The minister is asking the national treasury for an advance of the first billion and expects to issue bonds which will be sold abroad for another billion four hundred millions.

First Unit of Transit System for Pittsburgh Proposed

Extensive System for City and Suburban Area Outlined—Short Subway Made Part of This System

A RAPID transit system for the city of Pittsburgh, Pa., which will relieve the congestion in the narrow streets of the triangle district (a district analogous to the loop district in Chicago) and at the same time tend to spread the district across the Allegheny River, is proposed for the city in a report of the Traffic Commission, Bureau of Traffic Release, prepared by Daniel L. Turner, consulting engineer to the commission. The reason behind this report is the desire on the part of the city to determine how best to use the $6,000,000 voted in 1919 for the construction of a subway in the first and second wards. The report recommends a location for such a subway and outlines what its general characteristics should be. It also recommends the general routings for a metropolitan transit system to be built up around the first unit.

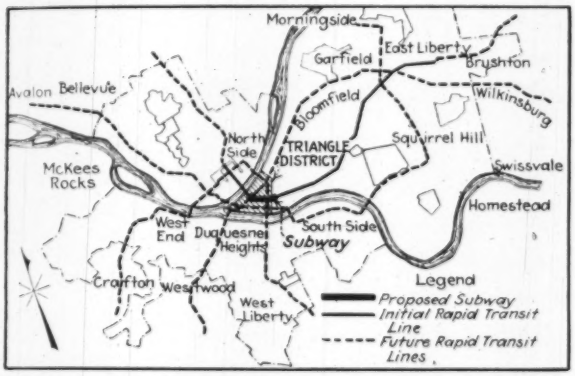


FIG. 1—PROPOSED METROPOLITAN RAPID TRANSIT SYSTEM FOR PITTSBURGH, PA.

The central business district of Pittsburgh is located in what is known as the triangle, a small area restricted by rivers on two sides and hills on the third. In this area, the streets are narrow and congested with street-car, motor and pedestrian traffic. Without resorting to street widening, the only way to reduce the congestion is by removing the surface cars from the streets subways or substituting a rapid transit system.

In considering this situation, the report points out that the cost of a street-car subway is about the same as that of a rapid transit subway, but its passenger carrying capacity is only half that of the latter. However, as the report finds that Pittsburgh does not require a complete metropolitan rapid transit system now and yet does need to have the street-cars removed from the streets in the congested district, it recommends that a street-car subway be built and that it be designed for future rapid transit use and laid out along routes for the future metropolitan transit system. The report also recommends that legislation be enacted providing for the metropolitan rapid transit system, so that a right-of-way may be acquired in the metropolitan area, thereby permitting 5 miles of surface rapid transit line to be constructed for the cost of 1 mile of subway in the built-up parts of the city.

The initial line of this system, to be built as soon as possible, should, according to the report, extend from the North Side across the Allegheny River, traverse the business district by way of the subway recommended

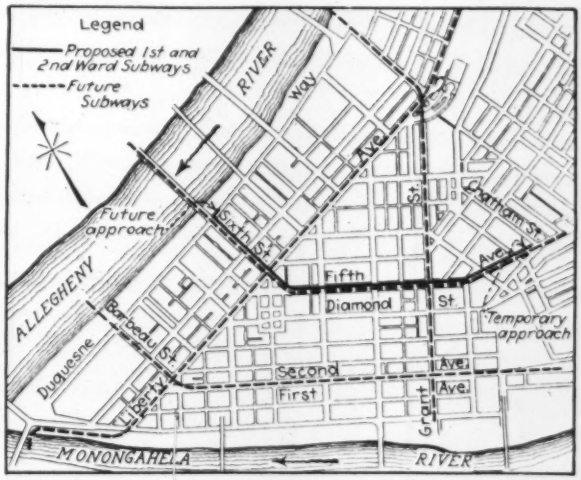


FIG. 2—PROPOSED SUBWAYS IN THE TRIANGLE DISTRICT

in the report, and extend on to East Liberty. The development of an "assessment financial plan" for financing this initial rapid transit line and the necessary legislation is recommended in order that it may be found possible to build the line in time to be operated in conjunction with the first and second ward subway to be built with money already provided, rather than to use this subway as a street-car subway for a short time.

The specific recommendations concerning the subway to be built with the $6,000,000 already provided are as follows: That a subway be built in the first and second wards under 5th Ave. and 6th St., between Duquesne Way and Chatham St.; that if sufficient additional money can be made available, a sub-street be constructed over the subway for pedestrian traffic, or that a continuous mezzanine be built over the subway if the full street width cannot be built. The estimated additional cost of the sub-street is $950,000. If it is decided not to build the initial rapid transit line at this time and consequently that this subway is to be used for street-car traffic, temporary approaches are to be built at Duquesne Way and Chatham St.

Subway Extensions for London

Considerable extension of the subway system in the southern part of London, England, is proposed in order to provide better transportation for the suburban districts. It is stated that these districts, with an area of 68 square miles and a population of 2,000,000, have only 11 miles of subway line, as against 58 miles in the northern section with 50 square miles and 2,500,000 population. In the southeast, the nearer suburbs consist manly of workmen's dwellings, while the farther suburbs are still largely rural and are not being developed rapidly owing to the lack of adequate transportation facilities. In 1924, the London subway lines carried 298,000,000 passengers; buses, 1,264,000,000 and street cars 180,000,000, with 70,150 and 19 million car-miles respectively.

Some Suggested Ways of Controlling the Mississippi Floods

Why the Mississippi River Commission Sticks to "Levees Only" Policy and Does Not Advocate Spillways, Reforestation, Reservoirs or Contour Plowing

By Charles L. Potter
Colonel, Corps of Engineers, U. S. A.; President, Mississippi River Commission, St. Louis, Mo.

This is the second of two articles by the President of the Mississippi River Commission on the methods of control on the longest fully regulated river in the world. The first article, published last week, described the differences in the control systems of the three sections of the river. This article is an authoritative defense of the "levees only" policy in flood control below Cairo.—Editor.

THE Mississippi River Commission has been much criticized, particularly in the extreme lower river, for adhering to its policy of levees only, in its flood control plan. Demand is made that instead of confining the flood within levees, carried to the necessary height, steps be taken to reduce the flood level. Many plans are suggested, some of which may be classed as reasonable (although not necessarily advisable) some as unreasonable, others as wild. Among those most often advanced are spillways or outlets, reservoirs, reforesting and contour plowing.

Spillways—This subject has been much before the public in one section of the Valley since the flood of 1922. To the layman, and to some engineers, the problem seems simple enough. If 25 per cent of the water be taken out of the river at any point, the remaining water must pass on at a lower level. Weir formulas and hydraulic laboratories will show that to be a fact. If however, the level is lowered at any point, it is self-evident that the slope of the river must be increased above that point and reduced below that point. Gulf level fixes one end of the slope and the lowering effect must cease at some point above the spillway. Between those two points the natural river slope may be considered as a straight line. If one point in that line is lowered, there must be greater than natural slope in that part of the line above, and less than natural slope in that part of the line below that point. Slope is one of the factors that determine velocity. Other factors being little changed, the velocity must be greater than the natural velocity above the spillway ; less below it.

Velocity determines the silt-bearing capacity of the river. The river enters the province of the spillway heavily charged with sedimentary matter. The increased velocity it begins to assume will certainly not be conducive to a greater loss of that charge than would have occurred with the natural velocity. It should increase, due to the greater scouring effect of the increased current. In fact everything points to its approach to the spillway with a greater load of silt than it would have had under natural conditions. The river assumes, below the spillway, a less than natural velocity. Sedimentation at that point must occur, reducing the cross-section of the river accordingly. This must continue until the river is again able to carry off its portion of the sedimentary matter. This it can only do by increased velocity. Increased velocity can only be obtained by increased head. Increased head means a recurring increased flood level. The result will be that when the spillway is opened there will be a temporary lowering, to be followed by sedimentation, and that necessarily accompanied by increased level, until an equilibrium is established between the bar-forming tendency and the velocity, at which point the bar will cease to rise.

The commission maintains that the spillway will be a disappointment; that the results will not be those shown by weir formulas or by a hydraulic laboratory; and that it cannot justify the expenditure of $5,000,000 to $10,000,000 in a demonstration which it thoroughly believes will be a failure, or so disappointing as to amount to a failure. The exponents of the spillway believe it will be a success. The commission does not. They will not be satisfied short of actual construction and demonstration, and the commission will not recommend it.

It is the function of the engineer first to apply figures. Even if figures prove him right, he must study precedents. If precedents are lacking he must study analogies. Figures prove the spillway a success; precedents are lacking; but unfortunately we have had analogies in many crevasses in the levee line. These are natural spillways, with the crest of the weir at bank level. Many surveys have been made and there is no doubt that the immediate effect of a crevasse is to form a bar in the river below it; and that in a short time the water levels rise again, due to the reduced capacity of the stream. The spillway enthusiasts claim that a controlled spillway will not act like a crevasse. The commission cannot see it that way. In fact the crevasse has the advantage of getting natural relief from the obstructive bar formation below, and consequent increased head, by widening out and carrying an increased volume of water.

If a spillway is to be installed near New Orleans, it should be above rather than below the city. Practically the entire New Orleans front is built up with wharves. The underwater bank is very steep and the water very deep. The banks have been formed by the river, through the ages, and under conditions of normal current. Their equilibrium is none too stable; many sections have had to be revetted; and some have had to be buttressed under water to prevent settling under the added load of the wharves. New Orleans had better be in the region of the reduced current (below the spillway) rather than in the region of increased current —above the spillway—for the safety of its wharves.

Reservoirs—This, like the spillway, seems a simple problem. Water held back cannot come down to increase the flood. But the water must be collected either at the point where it falls, or below that point. The winter and spring rains that produce our floods come in from the Gulf, pass up the Mississippi River to the

Ohio, and thence up the Ohio Valley and over the mountains. Normally they do not extend far to the westward of, or far northward on, the main river. Thus the headwaters of the Red, Arkansas and Missouri (excellent sites for reservoirs, with areas of waste or cheap land) are in regions where there is little rainfall, and what there is does not normally come at the season to augment the lower-river floods. Reservoirs in these regions would not justify even the reduced cost. In the lower reaches of these tributaries, where our flood-producing rains do fall, land is too valuable to be used for reservoir purposes. The same is true of the Upper Mississippi, although not in a region of so limited a rainfall. In the Ohio Valley, whence come three-quarters of our flood volume, the rainfall may be quite uniformly distributed over the valley; it may be largely confined to the area north of the Ohio River (in Ohio, Indiana and Illinois); or it may be largely south of that river (in Kentucky and Tennessee). Therefore the whole area must be so thoroughly covered with a reservoir system that one-half of that system may be able to do most of the work of holding back flood waters.

It has been estimated that, in order to reduce flood level 2 ft. at New Orleans, a reservoir 15 ft. deep at Cairo would have to cover 7,235 sq.mi. or 4,630,400 acres (seven-eighths of the area of the state of Massachusetts), having a capacity of more than 3 trillion cubic feet. In the rolling lands of Ohio, Indiana, Illinois, Kentucky and Tennessee, it is doubtful if there could be found large reservoir sites where an average depth of 15 ft. could be stored. Assuming it could, land for such reservoirs, covering rich farms, highways, railroads, and even towns, could not be had for less than an average of $200 per acre, representing a cost for land and damages of nearly a billion dollars. If we double that, to provide for all the storage in one-half the area (shown above as possibly necessary), we are piling up costs unknown to anything but war, running the government and bonus legislation. In the mountainous regions, reservoir sites could be found giving greater depths, but less area, and with less value to lands. But if the rainfall occurred largely in Ohio, Indiana and Illinois, as in 1912, reservoirs in the Appalachian Mountains could not do much good. However the cost outlined is for land and damages only, and there are many other elements of cost besides these.

Reservoir advocates have called attention to the fact that Pittsburgh has worked out a system of reservoirs which will, if built, reduce flood heights at their city by 10 ft. That will be fine for Pittsburgh, but what effect will that have at New Orleans? Colonel Townsend estimated that if the three main rivers (Ohio, Mississippi and Missouri) had been entirely cut off at Pittsburgh, St. Paul and Sioux City in the flood of 1913, it would have reduced the maximum flow at Columbus, Kentucky, by about 2½ per cent. This would have been scarcely observed at New Orleans. The flood-producing rains fell below Pittsburgh.

They call attention to the Miami Valley in Ohio, where a system of reservoirs has been built which is intended to hold that river within its banks. They overlook the fact that for a watershed of 3,800 sq.mi. the Miami Valley has expended on this reservoir system $32,000,000—$8,420 per square mile. The Ohio Valley covers 204,000 square miles. To reservoir the Ohio Valley at that rate would cost $1,718,000,000. The Miami Valley is small and may miss the heavy rains. It is short and the runoff occurs rapidly, therefore the reservoirs may, even in a great flood year, be emptied early enough to allow the cultivation of the lands within the reservoir area. It is probable that crops may be raised, or animals grazed, within the reservoir areas nine years out of ten. This, with the fact that the valley has been so developed industrially that the damages from floods were very great, probably justified the expenditure. Should other small valleys follow suit, it would not solve the flood problem. Communities, as well as individuals, look out for themselves. Nothing but federal control could prevent them from emptying their reservoirs in time to get a rental for their reservoir bottoms, even though they might be pouring out their discharge at such a time as to increase the height of floods from other parts of the Ohio Valley.

An illustration of the futility of trying to affect floods by isolated reservoirs may be had from the system of reservoirs which the government has built at the headwaters of the Mississippi. On these six reservoirs, even where natural lakes existed and most of the land was reserved from entry (without cost), the government has expended $1,634,000 for the storage capacity of 97 billion cubic feet. They are intended to store water in the spring season, for increasing the low water flow in the main river during the summer and fall. Of course they reduce floods immediately below, as well, but this effect is scarcely noticed at St. Paul. They are normally able to increase the low water depth at St. Paul by about 2 feet. But what do they do for floods in the lower river? Water accumulated prior to April 1 is all that could augment such floods. In 1921, when we had no flood in the lower river, these reservoirs accumulated from January to March, inclusive, 10 billion cubic feet. In the same months in 1922, when all possible help was needed, they were able to accumulate only 2 billion cubic feet, and they collect at that season everything above an estimated low water discharge—all they can. The 2 billion cubic feet that these reservoirs, on which $1,634,000 has been expended, were able to hold back out of the flood of 1922 is equal to the above-bank flow below Cairo, in a great flood, for 33 minutes. The river was above a bank-full stage at Cairo, although of course not at the highest, for 52 days. Again these reservoirs helped against no flood in 1921 just five times as much as they were able to help in 1922 against the greatest lower river flood ever known, and yet a much greater proportion of that flood than usual came from the Upper Mississippi. The Ohio had only a moderate flood. In the flood year of 1922, these reservoirs had to discharge more than 4 billion cubic feet in June to maintain a navigable depth at St. Paul, while in 1921, a year of no flood, they accumulated 7 billion cubic feet in June.

If the commission had unlimited funds, and if it were economically justified in destroying large areas of valuable farming lands, the flood problem could be solved by reservoirs, but the solution would be thoroughly unreasonable from either standpoint.

It has been stated above that communities are looking out for themselves. Before the Flood Control Committee of the House of Representatives, some two years ago, a New Orleans engineer criticized the commission very severely for shutting the water out of the delta basins above Red River—claiming they should be kept open as natural reservoirs for the flood waters, thus protecting the territory below Red River—and that

engineer was recently a prominent candidate for membership on the Mississippi River Commission.

Reforesting—May I be excused if I change from the third person to the first person, in discussing this subject? "It is believed" might lead to the assumption that it is generally conceded; while "I believe" fixes the responsibility definitely. I am not going to attempt a discussion of the effect of forests on rainfall. I am no climatologist. I have never been able to decide whether rainfall produces the forests, or the forests produce the rainfall. I shall limit my discussion to the effect of forests on runoff. In the arid west, on the upper reaches of the western tributaries, there are no forests, never have been any forests, and the ground is too dry to raise forests. Again there is little rainfall to be retained. Therefore effective reforesting must be done in the Upper Mississippi and Ohio Valleys. Except in the mountains and swampy regions (and the swamps are being drained and utilized for agriculture), forests have in general given place to farms. It has long been my theory that cultivated land is more obstructive to runoff than forests. It is also my theory that lands cut over and not turned into farms soon become, through the growth of scrub and brush, as much of an obstruction to runoff as were the original forests; if not more so. Therefore whichever happens—forward to farms or backward to wilderness—deforestation has little effect on runoff, except temporarily.

I arrived at my second, and confirmed my first, conclusion from a study of reservoirs at the headwaters of the Mississippi, while stationed in St. Paul. Of the six reservoirs, the upper two are (one on the main river and one on the Leech River and not far from their junction) Winnibigoshish Lake and Leech Lake. Some distance below the junction is Pokegama Lake and below that is Pokegama Dam across the main river. Above that dam is an area of watershed of 3,265 square miles, including three large reservoirs (85 per cent of the total reservoir capacity), which has been "fenced in" so to speak since 1885. All runoff, except that evaporated from the water surfaces, passes through Pokegama Dam. Daily observations have been taken on rainfall at the three dams for 39 years, and daily records of discharge have been kept, the latter from carefully prepared curves showing the discharge for any adjustment of the gates. The storage capacity of each reservoir is accurately known for each tenth of a foot difference in level. Thus we have an area on which the rainfall and runoff have been carefully recorded for 39 years. When the dams were first built (of timber, since replaced by concrete) all supplies had to be hauled by team straight through the virgin forest for more than a hundred miles. Not a railroad or a wagon road existed in that basin. Hauling had to be done in winter, when snow, covering the inequalities of the ground, formed the road metal and ice supplied the bridges and trestles. It is plain that deforestation had not yet begun.

Today there is no forest left. When the government (about 1900-1905) sold off timber for the benefit of the Indians (a considerable portion of this basin is Indian reservation) it specified that a few pine trees per acre be left standing to furnish seed for reforesting. Many of these trees, lacking the protection of the original surrounding forest, have been blown down.

I have no data as to when deforestation began. I know that in 1905 the Indian lands were being logged and the other lands had been pretty well cut over. That was my first visit to that country. In that year occurred the greatest rainfall of the 39 years (37.2 inches) and a very high runoff (35.8 per cent). The reservoirs were full and running over. Interests above were demanding that the sluice gates be opened to relieve them from flood, and those below were demanding that the gates be closed to relieve them from flood. I was one of a board of three army engineers to adjust differences. The land is poor agricultural land and quite a portion of it is Indian reservation. So it has largely gone back to scrub, although some of it has been settled, principally by the Scandinavian labor that did the logging, and became attached to the land, possibly from its resemblance to their native lands.

Of the 3,265 sq.mi. in this watershed, 584 sq.mi. are water surface. The locality is such that evaporation and rainfall are practically equal. So the runoff passed through Pokegama Dam, or stored in the reservoirs, is that from the remaining 2,681 sq.mi. of land surface. I first began this study in 1913, when the record covered 28 years. I divided the time into four 7-year periods. These were long enough to give fair averages; gave equal divisions of the time; and represented, to my mind, a good division as to conditions. The runoff percentages were as follows:

	Per cent
1885-1891 (Primeval conditions)	20.2
1892-1898 (Deforestation begun)	22.7
1899-1905 (Most active deforestation)...	34.2
1906-1912 (Partial relapse to scrub)....	23.7

This indicated that deforestation had done its worst, and that relapse to scrub was bringing the runoff back to its primeval rate. I looked for even greater improvement as time advanced.

I have recently obtained the records for the past 11 years, bringing the data down to date. For the full 11 years the rate of runoff has been 23.1 per cent, a drop of 0.6 since 1912. Taking the last 7 years, for comparison with my original 7-year periods, the runoff is reduced to 19.0 per cent, or 1.2 per cent below anything recorded. A visit to this area in the summer of 1923 showed a full growth of scrub, and increased farming. This is why I maintain that land, cleared of timber and gone back to scrub, as has probably 80 per cent of this area, is equal to, if not greater than, the original forest in reducing runoff. As more of this land goes under cultivation, the runoff will be less. This brings me to my early theory, that farms are better than forests in reducing runoff.

When I went to St. Paul in 1912, I found an approved project for a reservoir at Lac qui Parle on the Minnesota River. It was to hold 30 billion cubic feet of water; was expected to collect that much in years of low rainfall; and there was to be a surplus of 15 billion cubic feet with the normal rainfall. In the absence of definite data, the runoff had been assumed to be equal to that above Pokegama Dam—21 per cent. As the Minnesota River runs through highly developed agricultural land—the great grain belt—I was not satisfied to accept a runoff percentage as high as 21. From three years' discharge measurements by the Geological Survey on the Minnesota River, and from the rainfall records for the same time, I was forced, after careful study, to the conclusion that a 5 per cent runoff would be large for the Minnesota Valley—the three years' observations gave less than 3½ per cent. In those three

years a total precipitation in the reservoir basin above Pokegama Dam of 443 billion cubic feet gave a runoff of 79 billion, while in the Minnesota Valley a total precipitation of 943 billions (113 per cent greater) gave a runoff of only 30 billions, about 38 per cent of that above Pokegama, and exactly enough to fill the proposed Lac qui Parle reservoir once. Evaporation from the reservoir surface would have reduced the 30 billions to 24 billions. With a rainfall practically the same, with climatic conditions differing but little, and with no other decided difference except that one was in cultivated land and the other in the wilderness, the percentage of runoff was nearly six times as great in the wilderness as in the agricultural section.

With a definite showing that abandoned cut-over land is equal to, if not better than, forest in reducing runoff, and an equally definite showing that agricultural land is six times more effective than the cut-over land, I have no hesitancy in stating that, although there are many arguments in favor of reforesting, its effect on reducing flood levels is far from the most conclusive. Reforesting will not help us.

It may here be stated that the greatest flood ever known at St. Louis occurred in 1844, long before the woodman's axe had destroyed the forests in the upper valley.

A warning to the hydraulic engineer: Don't measure your percentage of runoff for one or two years and assume that you have it. Much depends on conditions preceding your measurements. A section of the table of runoff above Pokegama Dam will explain what I mean. The average rainfall for 39 years has been 25.8 inches.

Year	Rainfall In.	Total Precipitation Billion cu.ft.	Runoff Billions	Per Cent of Runoff
1915	29.5	184	52	28.1
1916	27.2	170	61	35.9
1917	15.4	96	28	29.2
1918	20.7	129	17	13.2
1919	30.0	187	39	20.9
Average	24.6	153	39	25.5

In 1916, following a wet year, and when the ground was full of water, the percentage of runoff was nearly three times as great as in 1918, a year of low rainfall following a year of very low rainfall. The actual runoff for 30 in. of rainfall in 1919 (39 billion cubic feet) was only 64 per cent of that from 27.2 in. of rainfall in 1916, and less than 40 per cent greater than that from a 15.4-in. rainfall in 1917. Where there are great variations in rainfall, you must have a normal year preceded by a normal year in order to get a fairly correct result from a single year's observations.

Contour Plowing—There is little doubt that if every farmer in the valley would plow along the contours, turning a back furrow every yard; would harrow, furrow and plant along those lines; and preserve these ridges even when put into grain and hay, some water would be held back. But who is going to make the farmer in Illinois plow his land in all sorts of irregular lines, leaving irregular ridges for his mowing machine and harvester to run over, in order to reduce, in a slight measure, the chances that a sugar planter in southern Louisiana may be flooded? In normal years the Illinois farmer will have about what water he needs. In flood years he will have too much. Is he going to soak his land in normal years, and doubly soak it in flood years, by holding back surplus water? Occasionally he would improve his conditions by holding back some water, but he will not know it until the water has gone. In 1912 some thirteen inches fell on the farm lands of Indiana and Illinois in an incredibly short time. Is it to be supposed that the farmer was anxious to retain, or could have retained, any great amount of that water on his land? He had a surplus and he was not interested in holding it on his land, to its detriment, in order to keep it off some down-river planter. If the farmer would not drain his swamps, it would help a lot. But who can deny him that right? All sections are selfish; each thinks the other should be altruistic—note the attitude of the New Orleans engineer, cited above.

Wildcat Theories—Just a few samples. One individual offered to carry a depth of 100 ft. from the Gulf to St. Louis, by directing the strong surface current to the bottom and flushing out all sediment. How the inversion of the river was to be accomplished, has never been developed.

Another suggests that the bottom current, which contains the greater part of the sediment, be conducted away in pipes. The destination of this water and sediment is still unknown.

Another suggests that the Missouri, at its mouth, be filtered, to get the sediment out of the river, and evaporated, to reduce the flood. It has never been determined as to where the necessary coal for such mechanical operation is to be found.

Just now a gentleman in Michigan has a scheme whereby floods may be reduced "any amount desired." When approached as to the nature of his plan, he declines to divulge it. We may yet learn the secret, and our troubles be over.

A congressman from one of the lower valley states sends a letter from a judge in his district, stating that much valuable land on a certain tributary would be saved from overflow if the commission would lower the flood level at the mouth of said tributary. The congressman asks if the commission had ever thought of that. The commission had thought of it; agreed as to the conclusions; but had to admit it didn't know how to do it.

Such suggestions have to be answered courteously and with apparent seriousness. The commission is often criticized because it does not hasten to adopt suggestions made to it. People think it so committed to archaic ideas that it will not accept suggestions from the outside—is unwilling to admit that any one from the outside can tell it anything. On the contrary, it is glad to hear any suggestions. But when a man comes in with the same old thing that has been considered, possibly tried and discarded—nothing new about it except a name—the commission cannot go all over the ground again. The public is loath to give credit for the amount of thought the commission has put on river problems—thinks it obstinate when it adheres to principles that have been proven by forty-five years of careful study and observation.

There is more wasted ingenuity, unsupported by technical knowledge, applied to the control of floods in the Mississippi River than to any other problem in the United States. The public thinks it an unsolved problem, and expects that Yankee ingenuity, rather than deep study along the lines of hydraulic engineering, is going to hit upon a solution.

Los Angeles Plans 268-Mi. Aqueduct from Colorado River

Ultimate Supply of Nearly a Billion Gallons a Day to Be Pumped 1,416 Ft. in Five or Six Lifts—15-Mi. Filtration Gallery

THE CITY of Los Angeles has spent about $100,000 on investigations of an aqueduct that might be built to bring water from the Colorado River to the city limits, a distance of 268 miles, or 18 miles more than the length of the aqueduct from Owens Valley. Filings have been made on the diversion of 1,500 sec.-ft. (970 m.g.d.) of Colorado River water and although detailed plans or even final location of the route cannot be made until the scheme takes more definite shape considerable data have been collected under the direction of William Mulholland, chief engineer, Los Angeles water and power bureau. Previous reference to this investigation appeared in *Engineering News-Record*, Aug. 14, 1924, p. 277. Some of the features of the work recently described to a representative of this journal by Mr. Mulholland are presented here:

Surveys and other field work have been under way for more than a year. Four parties are now in the field and a limited force is working on comparisons and estimates in the Los Angeles office. Although no actual estimate of cost can be made until studies progress further it is believed that the estimate will be somewhere between $100,000,000 and $150,000,000.

Instead of using the ordinary form of river diversion and intake, the first 15 miles of the aqueduct at the upper end would be located in the gravel beds that lie between the banks of the river and the Maria mountains. This would constitute a filtration gallery into which Mr. Mulholland believes there would be a constant flow of water free from silt. This plan would solve the silt problem and avoid the expense of constructing and maintaining an intake.

There are two fixed points through which the aqueduct must almost certainly go no matter what other location changes are made. About 25 miles from the upper end of the aqueduct there is a pass, El. 450, between the Chuckawalla and the Palo Verde valleys and again about 80 miles from the upper end, Shaver Summit, El. 1706, which separates Chuckawalla and Coachella (Imperial) valleys as a controlling point. Except at these two points the location could be shifted so as to concentrate or to separate the lifts, to change the length of tunnels and otherwise to alter the principal features. If power costs were to be low, higher lifts could be used to save tunnel costs. The balancing of interest charges on an expensive location against the pumping cost on a cheaper line is typical of the economic studies yet to be made before the definite location can be selected.

It is believed, however, that a net lift (exclusive of the friction head) of 1,416 ft. will be necessary. This lift must be made in several plants east of Shaver Summit, the remaining 190 miles on the west end will not require pumping plants with the possible exception of a small plant near Cabezon.

A total of about 75 miles of the aqueduct would be in tunnels and one of the tunnels would have a minimum length of 14 miles on which the driving could be done from the two ends only. This long tunnel would be under Beaumont Pass, El. 2,556, at the north end of Coachella Valley. All the tunnels would be west of Shaver Summit and for the most part would be in granite or limestone since it is believed possible in most places to avoid loose formation and the glacial drift.

Either five or six pumping stations are favored as an economic number. Greater concentration of pumping units would decrease operating costs but would greatly increase initial costs on account of the thicker pipe required for the higher heads. A tunnel section of 12x16 ft. might be used although this and the question of grade are to be balanced to find an economic mean. The power required for pumping will amount to about 200 hp. per sec.-ft. for the total lift.

From Beaumont Pass westward both pressure and hydraulic locations have been considered, with preference for the latter on a location following the foothills to Pasadena. Pasadena's proposed 65,000-acre-ft. storage reservoir at Pine Canyon on the San Gabriel River, El. 1220, is being considered as one of several distribution reservoirs into which this aqueduct might flow.

Unlike the Owens Valley aqueduct, transportation would not be a difficult problem anywhere along the proposed Colorado River aqueduct, as nowhere does the location get very far from main line railroads.

Report on Government Railways in New South Wales

ALTHOUGH severe conditions of grade and curvature characterize the lines of the New South Wales Government Rys., in Australia, the topography of the country is such that there is little opportunity for improving these conditions by relocation, except at enormous expense, according to the report of the British commission which recently investigated the construction and operation of these railways. The maximum grades on different routes are from 3.2 and 2.5 per cent to 1.6 and 1.4 per cent. The total length of the railway system is 5,523 miles, with 6,261 miles of track.

Standard track construction consists of 80- to 100-lb. T-rails (60-lb. for pioneer lines), with eighteen ties to a 40-ft. rail length; the ties are of hardwood, 8 ft. long and 4½x9 in. in section. Stone ballast is of 3-in. size for the lower portion, topped with 2½-in. stone. Earth ballast is used on pioneer lines, supplemented by gravel, sand or cinders where necessary. The average life of rails is given as 18 years for 100-lb.; 20 for 80-lb., 40 for 71½-lb. and 25 for 60-lb. rails. That the track in general is noisy is stated in the report, with the suggestion that experiments should be made to eliminate this objectionable feature. Axle loads are limited to 20½ gross tons on main lines and 13½ to 17½ tons on branch and pioneer lines, according to the weight of rail.

Transfer of the railways to private management is not considered necessary, since the commission considers that if its recommendations are carried out the value of the property will soon be sufficient to repay the state for bearing the burden during earlier years. A weak point is the system of financing, under which the requests of the railway commissioner are largely ignored by the government, so that he never knows how much money will be available for necessary works and the net result is excessive cost of work done in piecemeal manner.

Long Spans of Hudson River Bridge Erected by Progressive Cantilever Method

Alfred H. Smith Memorial Bridge Constructed by Special Method Proposed by Contractor in Place of Falsework Method Originally Contemplated—Staying Pile Foundations—Driving Long Rivets

By H. T. Welty
Engineer of Structures, New York Central R. R., New York City

SUPERSTRUCTURE erection on the New York Central R.R. new Hudson River crossing, at Castleton, a short distance south of Albany, known as the Alfred H. Smith Memorial Bridge, was distinguished by a radical change in the erection plan first contemplated and contracted for. The method actually carried out was cantilever erection, using temporary steel supports at intermediate points of the span length. The two long steel viaducts forming the approaches were erected by two somewhat different methods, controlled by the facilities for access and material supply.

An outline of the project and its development, and notes on the structural design, were given in a previous article (*Engineering News-Record*, March 19, p. 466).

Original Erection Program—The original scheme of erection contemplated the following procedure:

1—Erection of the west viaduct, starting at the west end, where material could be delivered on a temporary track connection.

2—Erection of the 600-ft. span on timber falsework, first dredging a temporary river channel between the center and east piers.

3—Erection of the 400-ft. span on timber falsework, returning river traffic to the regular channel.

4—Erection of the east viaduct.

On the east side of the river a track connection to grade level was not available, but it was planned to supply steel over a temporary track which had been laid along the viaduct location to a point near the east river pier for use during the construction of the foundations. The intention was to erect one tower of the east viaduct with a locomotive crane and derricks attached to the tower legs, in a manner similar to that used in the erection of steel buildings, then lift a special traveler into position on the tower, and erect the remainder of the east viaduct with this traveler lifting material from the ground below, supplemented as far as possible by the crane erecting the lower column sections from the ground level.

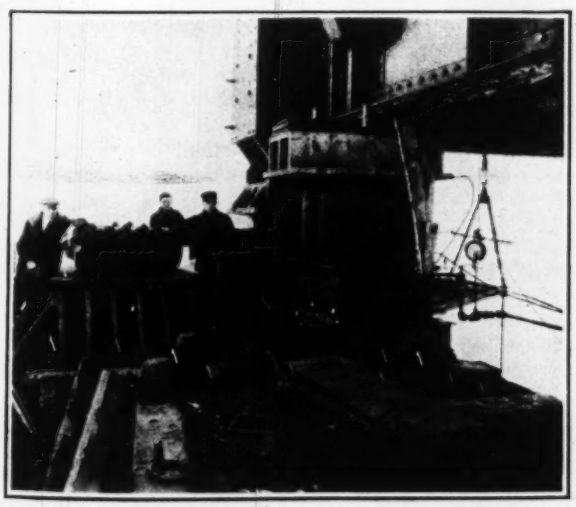


FIG. 1—LANDING 400-FT. SPAN ON ITS WEST PIER

FIG. 2—DECK TRAVELER ERECTING EAST VIADUCT

This program was generally followed in so far as the viaducts were concerned, but was abandoned in the erection of the truss spans. Building these spans 135 ft. above the water on timber falsework would have involved a certain amount of hazard, because of the danger of fire and the possibility of damage from high water carrying ice floes should the work extend into winter weather. After a careful study of the situation the contractor proposed a new scheme which contemplated the erection of the three easterly panels of the 400-ft. span on timber falsework and the remainder of that span and of the entire 600-ft. span by the progressive cantilever method, using intermediate supports consisting of steel bents resting on pile foundations. This change appealed to the railroad company, for it appeared that not only would the fire and ice hazard be thereby very much minimized but the necessity of dredging a temporary river channel would be eliminated. This method of erection was adopted.

Viaduct Construction—Erection of the west viaduct was started in November, 1922, and was completed in January, 1923. The east viaduct was started in May and completed in December, 1923.

The traveler used for the erection was built with steel side frames about 47 ft. long, supported on four two-

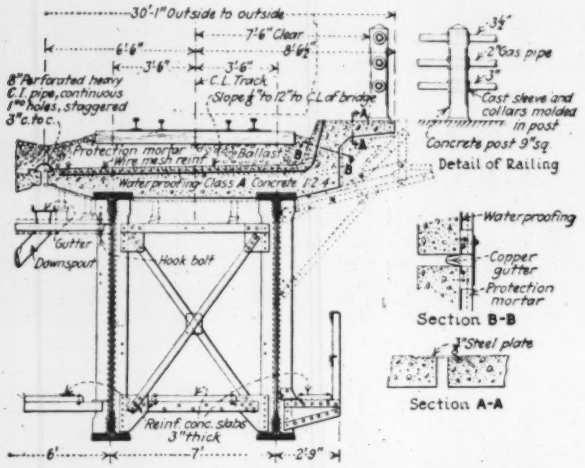


FIG. 3—VIADUCT DECK—METHOD OF SUPPORTING FORMS FOR CONCRETE

wheel trucks running on rails 20 ft. c. to c. laid on the two outside lines of viaduct girders as erected. The side frames were braced to overhead cross girders which gave a clearance of 16 ft. above a track laid on the two inside lines of girders, on which material was delivered. The side frames were clamped to the viaduct girders fore and aft, and a special jack bearing was provided immediately under the lower boom casting while lifting loads. An overhead platform carried the operating equipment. The 110-ft. boom had a capacity of 50 tons with a reach of 52 ft. and a sideswing of 10 ft., and a capacity of 20 tons with a reach of 101-ft. and a sideswing of 22 ft. These loads were the limits of those to be lifted at the reaches mentioned.

Upon completion of the steel erection of each viaduct the concrete deck was constructed as weather conditions permitted, the slab for one track on each section being completed before the adjacent slab was started, in order that material might be readily handled. Forms for the overhangs were supported on steel brackets attached to stiffener angles of the outside girders through holes provided in the shop for this purpose (Fig. 3). The brackets were moved forward as the work progressed, being used many times in the course of the work. Between girders, the forms were supported on the cross struts of the top bracing system. While the design drawings contemplated precast railing posts and inspection walks, the contractor elected to cast both in place. Remarkably good results were obtained in the pouring of the railing posts, considering the length of the viaducts and the great number of posts. They are all in perfect alignment.

Erecting the 400-ft. Span

The timber falsework to support the three easterly panels of the 400-ft. span consisted of a row of 30 piles under each of the first three panel points, driven to rock at approximately El.—32, cut off above high water at El.+9.35, and capped with 12x12 in. timbers. The pile bents were braced transversely with 4x8-in. cross-bracing. On the pile bents were erected five stories of framed bents, of 12x12 posts with 12x12 caps and sills and 4x8 cross-bracing. The bents were braced longitudinally by 10x12 struts at each story, with cross-bracing between of 1 in. rods. The bent at L 1 (points will be designated by the lower-chord panel point numbers) was also strutted to the east pier and tied to the pier with cable lashings. The tops of the bents were connected by steel beams on which, at each panel point, were placed rail grillages; on these the bridge floor-beams were blocked.

The elevations of the bents were carefully computed to provide a truss contour after erection (but before landing) such that there would be just sufficient jacking space at the center pier. Too much space would have necessitated excessive jacking to release the span from the center supports. In computing these elevations, settlement of the bents and compression of the posts and joints was allowed for by adding $\frac{1}{16}$ in. for a joint between a cap and a sill and $\frac{1}{8}$ in. for a joint between a post and a cap or sill, with other allowances for special points. The actual compressions observed in the field turned out to be slightly greater.

The timber falsework was erected by the viaduct traveler, which had already set about 330 ft. of the east viaduct. This equipment was also used to erect the first four panels of the 400-ft. span and the creeper traveler on the top chords, after which it was returned to viaduct erection. The creeper traveler was used for the remainder of the erection of the truss spans.

Because of the change in the method of erecting the truss spans it was necessary to deliver the steel at the low level on the east side of the river. To elevate this material to the upper level a steel hoisting tower was erected alongside the viaduct a short distance from the east pier, on which two derricks were mounted of sufficient capacity to raise the heavy chord members. The members were landed on small cars operating on a temporary track at the upper level.

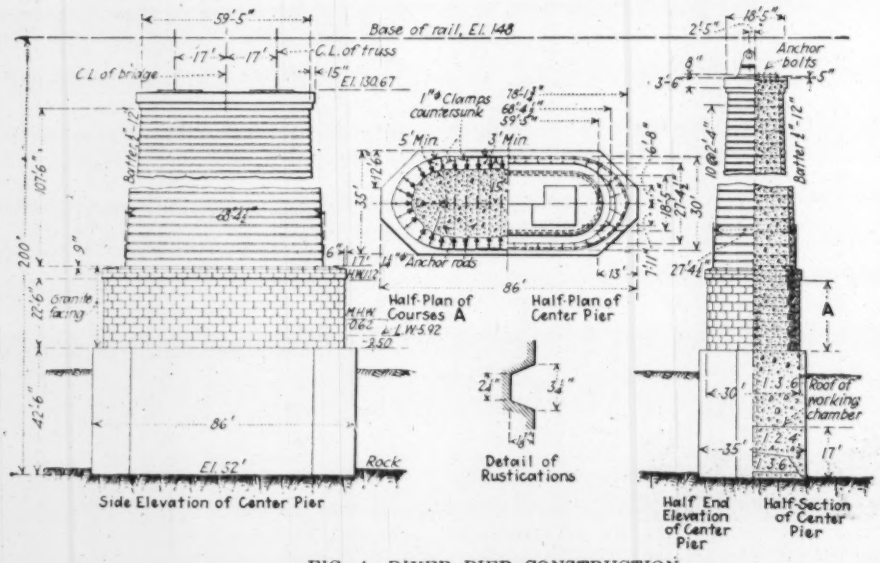


FIG. 4—RIVER PIER CONSTRUCTION

Pneumatic caisson foundation—Granite facing in water range, rusticated concrete shaft above.

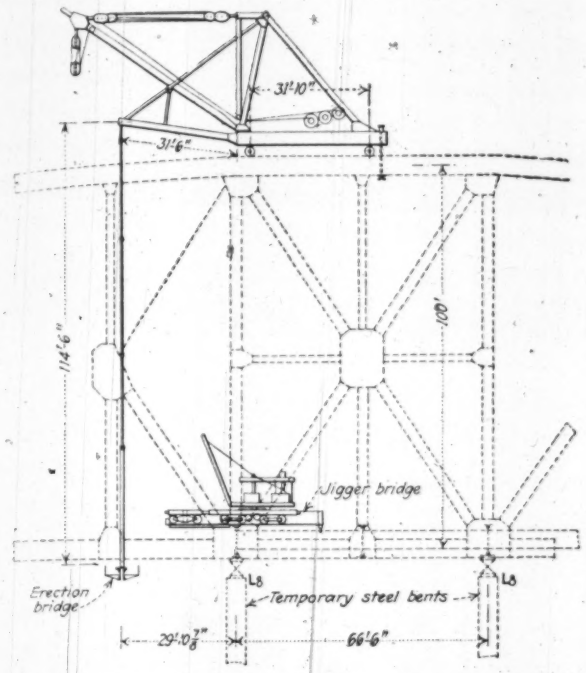


FIG. 5—CREEPER TRAVELER AND ERECTION BRIDGES

Creeper Traveler—Briefly described, the creeper traveler was a braced steel derrick platform on trucks running on rails laid on the top chords. The hoisting machines were located on this platform. At the front end a cross-girder supported two steel A-frame masts, hinged at the base to compensate for the inclination of the chords and permit a vertical position of the A-frames to be maintained, and two steel booms 55 ft. long, one for each truss, with braced backstays to the rear of the platform.

When in working position the creeper was held longitudinally by heavy steel stops bolted to the top chords and its rear end was anchored down to the chords, while the load at the front end was taken to the top chords through heavy screw jacks beneath the cross-girder.

Because of the inclination of the top chords, it was considered advisable to counterweight the creeper traveler while moving it from one position to another. On the 400-ft. span, the heavy west end floorbeam of the 600-ft span was used as a counterweight, being suspended beneath the bridge floor by steel cables attached to the traveler. However, this expedient proved rather unwieldly and expensive in operation, and it was discarded in the erection of the 600-ft. span.

At bridge deck level two "jigger" bridges and an erection bridge were provided. The jigger bridges were plate-girder spans about 39 ft. long projecting about 17 ft. beyond the last floorbeam erected, being supported on this floorbeam and anchored to the stringers at the rear end. The projecting 17 ft. was equipped with a suspended floor carrying an extension of the temporary track. These bridges, one for each track, were used to support material to be erected beyond the last cross-frame, so that the traveler could lift this material without fouling parts already in place and without pulling the boom falls too far back from a plumb position. The erection bridge was a cross-girder suspended in advance of the last panel point erected, by hanger bars from braced outriggers on the traveler. This bridge was equipped with a 50-ton Norton jack at each end, and supported the outer ends of the bottom chord members while they were being connected up. The jacks were for the purpose of adjusting the chords to the correct elevations to make the holes match.

Support on Temporary Bent—The creeper traveler completed the erection of such parts as had not been set by the viaduct traveler, to the fourth panel point. Here it set the first temporary steel bent on pile foundations already constructed by floating equipment (Fig. 6). Two bents were furnished for use in the erection of both spans, being dismantled and re-erected as the work progressed. The bents consisted of two posts, battered 1½ in 12, braced transversely, and with hinged bearings at the bottom to permit longitudinal movement of the span due to temperature changes. At the top they were connected to the bottom chords of the span by hinged struts extending one panel back on the span, which formed the only longitudinal support.

To obtain a satisfactory l/r ratio with no longitudinal bracing, it was necessary to design these posts with large lateral dimensions. Each post was made up of two webs 60½ in. deep, spaced 41¾ in. to each of which were riveted eight 6x6-in. angles and two 14-in. cover plates, giving a total gross area of 253 sq.in. The designing stresses were 18000 — 80 l/r lb. per sq.in. without wind and 24000 — 100 l/r lb. per sq. in. including a 30-lb. wind pressure on 1½ times the exposed area of the floor and one truss.

The heaviest column section weighed about 30 tons and the total weight of a bent was 262 tons. To facilitate erection and dismantling of these bents, all connections were bolted, the bearings of abutting column sections being on planed surfaces.

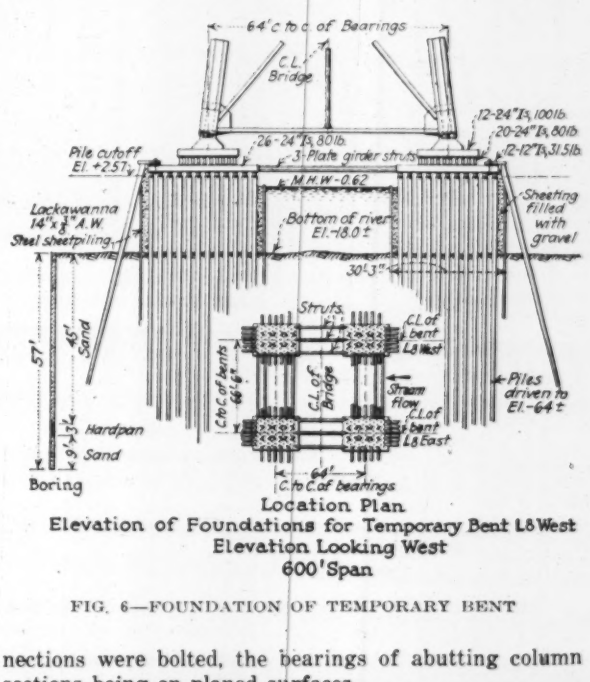


FIG. 6—FOUNDATION OF TEMPORARY BENT

The foundations of the first bent, that at L4, where the water was comparatively shallow, were simply capped pile bents, cross-braced above the water, there being 30 piles under each column of the bent. Each group of piles was further braced by three batter piles on each side. The caps supported a grillage consisting of two tiers of 24-in. steel I-beams on which rested the

column shoes. The piles were loaded to 24 tons each without wind, and about 33 tons including an assumed 30-lb. wind pressure.

The truss loads were carried to the bent through pin shoes bearing on the chord gusset plates, which had been planed in the shop so that they, rather than the chord angles, would take this load. Shims were provided under the shoes for the purpose of elevation adjustments. In addition to the truss shoes, each column cap was proportioned to support four hydraulic jacks arranged symmetrically about the shoe and also bearing on the gusset plates. By means of these jacks the proper bottom-chord elevations were maintained.

Second Support—From the fourth to the sixth panel points the span was cantilevered, the traveler being advanced by means of hoisting engines located on the deck level, and motors on the traveler itself. Under the sixth panel point another temporary bent was erected. This bent was a duplicate of that under the fourth panel point, but a change was made in the design of the foundations. At this point the water was about 13 ft. deep and there was more danger of scour. It was therefore decided to enclose each pile group in a steel sheet-pile cofferdam filled with sand, the sheeting being driven 8 ft. to 12 ft. into the river bottom. To brace the sheeting against possible pressure from the sand, a frame of 12x12 in. timbers tied together by 1¼-in. rods was placed around the cofferdam about 8 ft. above the bottom and a similar frame made of two 10-in. channels instead of timbers was placed near the top of the dam. To place the lower frame short pieces of sheeting were driven to the proper elevation to support the rods. After the cofferdam was driven, the frame was sunk into position with the rods in place, and short pieces of sheeting with their lower ends notched to fit over the rods were driven to fill the open spaces. Pieces of plank, similar to washers, had been placed on the tierods before sinking to close the notches through which the tierods passed and prevent the outflow of the sand filling. The tops of the cofferdams were about 5 ft. above mean high water, and there was no difficulty in placing the top frames. There were 39 piles under each of the L6 points, each cofferdam being 22 x 30 ft. in size.

After the trusses had been supported on the temporary bents at L6 East, they were jacked a sufficient amount to release the L4 bent, which was then dismantled and re-erected at L6 West, where foundations were the same as at L6 East.

Cantilevering Far Half of Span—From L6 West to the center pier the erection proceeded by the cantilever method, and when completed, but before landing on the pier, the span was supported on the two temporary bents, which were spaced symmetrically about the center of the span, two truss panel lengths apart. In the erection of the west half of the span, temporary diagonals were used between each top chord main panel point and the center of the main diagonal in that panel, connected by pins through the gusset plates and hinged at the middle to provide toggle action for adjustment, and to release the diagonals when they were no longer required. These diagonals made the material erected in advance of the traveler self supporting until the connections of main diagonals and top chords could be made.

The uplift at the east end due to cantilever erection was taken by 1½-in. anchor bolts engaging a steel frame composed of channels which, with the anchor bolts, had been set 15 ft. in the masonry during its construction. The anchor bolts were placed in 6-in. pipes to permit accurate adjustment for position before the base castings were placed. In addition to uplift, the anchor bolts were proportioned to take horizontal shear from temperature changes and wind, and such shear as might be produced by a deviation from the vertical of the temporary steel bents. A possible deviation of 6 in. east or west was assumed. To resist such shear, the anchor bolts were accurately positioned on completion of the pier, and the pipes were filled with cement grout to a point 4 in. below the top, above which the pipes were filled with spelter.

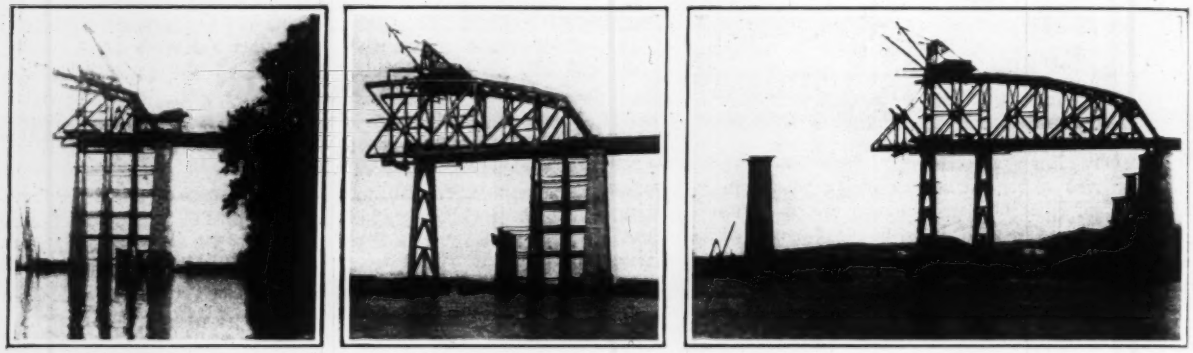


FIG. 7—THREE STAGES OF ERECTION OF 400-FT. SPAN (EAST RIVER SPAN)

Riveting—Field riveting of truss connections followed closely the erection of each member, so that all main members were fully riveted under a condition of practically no stress. The cross-frames and laterals were left bolted until the erection of the span had been completed, to facilitate adjustment for elevation and to avoid delay to important riveting.

The lengths of stringers had been computed for a loading condition of $D + \frac{1}{2}(L + I)$, or a straight bottom chord. The bottom chord being in compression during erection, the panels under this condition were shorter than under the condition of straight bottom chord, by an amount equal to the chord extension under $D + \frac{1}{2}(L + I)$ added to the shortening due to the erection stress. In order therefore that the floorbeams might be erected without difficulty and to insure that the stringers would take no chord stress with bottom chords in a straight line, the stringer connection angles were bolted to the stringer webs with ¾-in. bolts until the span was swung, when the lengthening of the bot-

tom chord permitted riveting of the connections with but slight forcing.

Center Diagonals—One of the most interesting details of the erection program was the omission of the center diagonals (in so far as stress transfer was concerned) until the span had been jacked clear of the temporary bents. Thus the span when completely erected but before jacking was in a condition similar to an open swing span without middle diagonals.

These diagonals were erected and riveted at their upper connections, but the lower connections were not drilled and riveted until the span was jacked into permanent position. Possible unequal settlement of the temporary bents was the consideration which led to this scheme. With the center diagonals connected the span would have been continuous over the temporary supports and a settlement of either bent would have immediately overloaded the other. With the center diagonals disconnected, such settlement would have resulted at worst in a slight bending of the chords of the center panel, with a much less overloading of the bents. Because of the high normal stresses in the bents, considering their unbraced length, it was thought safer to reduce a possible overloading to the minimum. The permissible bending of the chords was computed and a maximum permissible amount of settlement established. As mentioned before, jacks were in position on the bents, ready to operate at all times. Careful elevations were taken each day, but there was very little settlement.

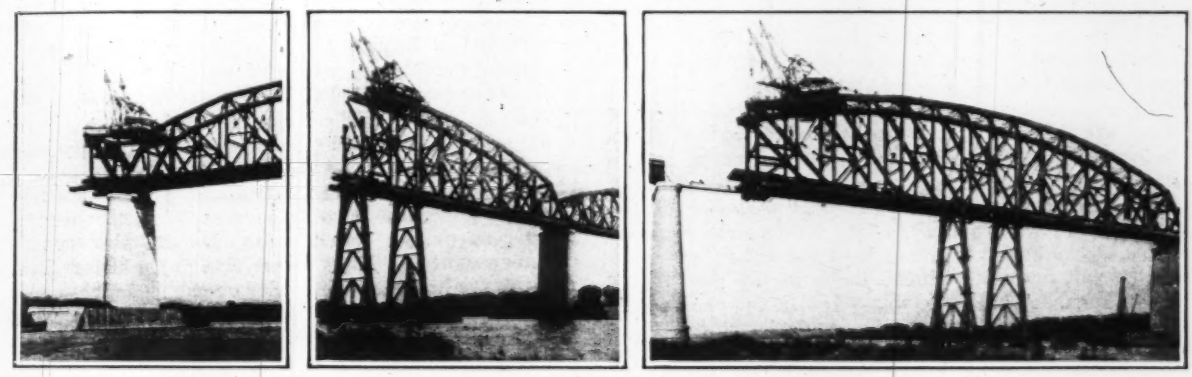


FIG. 8—ERECTION OF 600-FT. SPAN. (FIRST TEMPORARY SUPPORT USED BETWEEN STAGES 1 AND 2.)

Final Jacking—As soon as the span had been erected, two batteries of four hydraulic jacks each were moved from the L6E bent to the pier at the west end of the span, and placed under the west end floorbeam close to the trusses, bearing against the bottom flanges of the beam through large castings. The total load to be lifted was approximately 1,600 tons, which required special floorbeam design and support for the jacks by I-beam grillages on the masonry. In proportioning the floorbeam for this condition of loading, unit stresses 50 per cent greater than the regular stresses had been used.

The hydraulic jacks, which had a rated capacity of 500 tons each, were connected by flexible copper pipes, $\frac{1}{4}$ in. outside and $\frac{3}{8}$ in. inside diameters, to a steel header pipe, $1\frac{1}{4}$ in. outside and $\frac{5}{8}$ in. inside diameters, which in turn connected to a steel supply pipe, $1\frac{7}{8}$ in. outside and $1\frac{1}{8}$ in. inside diameters. The pipes were tested to 10,000 lb. per sq.in. water pressure. In the header near each battery of jacks a 10,000-lb. pressure gage was located. Inlet and outlet valves were located just beyond the gage, with the copper pipes to the jacks connected between.

The supply line ran to a duplex steam pump operated by air furnished from a compressor in the power house, acting on a 12-in. piston having a 16-in. stroke. The air pressure developed on this piston was from 115 to 130 lb. per sq.in. To multiply or "boost" this pressure, the air piston was connected to a smaller piston, $1\frac{3}{4}$ in. diameter, which acted on the water supply to the jacks. Thus the air pressure was multiplied about 47 times, less frictional losses. The efficiency of the jacks in making heavy lifts was about 90 per cent. The maximum gage readings, when the span was swung clear, was 3,200 lb. (5,400 lb. for the 600-ft. spans).

The pumps were located near the L4E panel points on both spans, these being the first points where the jacks were used. The jacks were 32 in. high and 20 in. square at the base, and had $12\frac{1}{2}$-in. plungers with a 15-in. runout. They weighed about 2,300 lb. each.

With the span swung clear, and before the center diagonals were connected, it was very desirable to have an absolutely balanced condition of load to avoid any permanent bending in the chords. The only unbalanced load at this time was the 225-ton creeper traveler, located over the second panel from the west end. For this load, the shear across the center panel was equalized by the traveler counterweight, which was suspended a sufficient distance east of the center.

At the time jacking started, the west end was $6\frac{1}{2}$ in. below its final elevation. The end lift was made in small amounts ($4\frac{1}{2}$ in. to $1\frac{1}{2}$ in.) in order to observe the action at the temporary bents. The jacking transferred load from the bents to the ends in unequal amounts, the tendency being for the west bent to release faster than the east bent. This at once produced shear across the center panel, with a consequent lagging in comparative elevation at the west bent. To correct this, the jacks on the west bent were operated alternately with the end jacks, but for smaller lifts, the effort being to maintain as nearly as possible the correct truss contour, thus equalizing the load on the bents and avoiding bending the chords. After each lift, all points were shimmed and elevations were taken, and after the second end lift the rollers were set. The total end lift was approximately 12 in., at which time the span was free at both bents. The excess lift over that required to set the rollers was due to the necessity of setting the L6 panel points at an elevation higher than their final elevation to compensate for the cantilever deflec-

tion of the west half of the span and allow jacking clearance.

With the shims on the temporary bents removed, the span was jacked down onto the rollers at the west end. Careful levels then showed that the L6 points agreed within ¼ in. in elevation; no attempt was made to get a more exact agreement, and the connections of the center diagonals were immediately drilled and riveted.

The 400-ft. span was landed early in January, 1924. The difficulties of winter work in this location were such that erection of the 600-ft. span was postponed until spring.

Erection of 600-Ft. Span

Having the 400-ft. span for an anchorage, it was possible to erect the first four panels of the 600-ft. span as a cantilever.

Spans Made Continuous—While the east end of the 600-ft. span was fixed and anchored to its pier like the east end of the 400-ft. span, the west end of the latter was the expansion end. It now became necessary to interchange temporarily the fixed and expansion ends of the shorter span. At the east end, the planed surfaces of the shoe and bearing castings had been heavily lubricated when they were erected. The connecting bolts were removed so as to permit longitudinal motion, any possible transverse movement being resisted by guide bars. At the west end the rollers were wedged tight. This arrangement worked very satisfactorily, as the east bearing moved freely under temperature changes.

The thrust from the cantilevered material of the 600-ft. span, was carried to the 400-ft. span through thrust blocks bolted to the ends of the 400-ft. span bottom chords, and with hinged joints at the ends of the 600-ft. span. A half hole was bored in the end of each 600-ft. span bottom chord to provide bearing for the 15-in. pin from the shoe at the west end of the span, which was temporarily used in the thrust block. To compensate for pin rotation and prevent jamming, a clearance of ¼ in. was provided in the jaw plates.

At the top chords the spans were connected by a tie, attached to each hip point by pins bearing on extensions of the hip gussets, reinforced with pin plates. These extensions were burned off after serving their purpose, the edges were chipped, and the slots in the cover plates were covered with splice plates.

The top-chord ties acted as track beams for the transfer of the creeper traveler from the 400-ft. span to the 600-ft. span, and for this service were supported at their centers on columns resting on the ends of the shorter span. These ties were released upon landing the span on the first temporary support at L4.

The erection methods followed in the erection of the 600-ft. span were generally the same as for the 400-ft. span, the main difference being that the members were larger and heavier, and the rivets in some of the chord splices were larger and longer. The foundations for the temporary bents were larger, each consisting of 72 vertical piles, and the water was about 20 ft. deep.

A Foundation Difficulty—When the erection had reached the sixth panel point some delay was occasioned by a movement of the foundation of the temporary bent at L4 due to an excessively high wind. This was corrected by jacking the foundations laterally against a special jacking bent composed of two rows of vertical piles and a single row of heavy batter piles, at the same time pulling against the top of the jacking bent by means of steel cables attached to pile anchorages, at the bed of the river. After the foundations had been restored to approximately their former positions, their outside faces were braced with batter piles wedged to the steel grillages to insure against further movement. Also to avoid any possible recurrence of this trouble, the foundations at the L8 points were similarly modified, and in addition interior batter piles were driven between the vertical piles and the cofferdams were filled with gravel, as it was thought that such materal would act as a more positive support for the piles than sand. The tops of the four foundations were braced horizontally, one to another, by struts, thus making them act somewhat as a unit. There was no movement whatever in the foundations, and only normal settlement.

Side Channel Required—At about this time, the navigation interests decided that a clear channel of 232 ft. between the west dike and temporary bent L8W, which had been considered satisfactory up to this time, would not be sufficient for the safe operation of river traffic. About 180 ft. of this proposed clear channel had a navigable depth of water. Hearings were held before the local Engineer Officer of the War Department and later before the Secretary of War, and the railroad company was finally ordered to dredge a temporary channel under the 400-ft. span, no work on the foundations at L8W being permitted until this channel had been completed. Little delay in erection resulted.

As soon as the dredging was completed, the L8W foundations and bent were constructed, and the erection of steel proceeded rapidly to the west pier by the same methods, generally, as were used in the erection of the shorter span. As stated before, the traveler was not counterweighted during the erection of the 600-ft. span, reliance for holding the traveler on the slope while moving it being placed on the hoisting engines, which proved entirely satisfactory.

Landing the Long Span—The span was about 4 in. out of alignment at the west end. This was corrected before the vertical jacking was started, by means of 100-ton screw jacks operating on the west pier. Part of this distance was made up by forcing the temporary foundations and part by a slight lateral deflection of the span itself. As the vertical lift was made, the horizontal jacks were operated sufficiently to hold the end of the span in correct position.

During the landing operations for the 400-ft. span, the jacking on the temporary bents had occasioned some delay, and it was desired to avoid this in the case of the 600-ft span. Plates were bolted to the lower outside faces of the center diagonals U8W-L8E which would take the unbalanced shear in compression, these plates being wedged against the gusset plates soon after the jacking started. This expedient eliminated all serious bending in the chords.

The total weight lifted was about 3,000 tons. Five of the hydraulic jacks were used at each end of the floorbeam. The total lift required to clear the bents was 20½ in., although only 15½ was necessary for placing the rollers. The span was jacked onto the rollers on Oct. 24, 1924.

Driving Long Rivets—Considerable trouble was experienced in getting the long 1-in. and 1⅛-in. rivets to fill the holes satisfactorily. Tapered rivets were used from the beginning, with a view to good upsetting, but this expedient was evidently not sufficient. While the rivets would test tight under the hammer, when cut out they would be found to be as much as 0.04 in. less in diameter than the holes, bearing only under the two heads. After

considerable experimenting excellent rivets resulted by (1) uniform, clean heating, obtained by using a mixture of coke and coal in an oversize forge, fed with 40 lb. blast from the air line; (2) use of heavier plungers in the riveting hammers; (3) slightly quenching the ends of the rivets before driving, to insure initial upsetting inside the holes; (4) making the taper as long as possible and the diameters such that the shop head would stand a slight distance from the metal when the hot rivet was inserted (in other words, making the rivets to fit the holes as tightly as practicable before driving); and (5) countersinking the holes $\frac{1}{32}$ to $\frac{1}{8}$ in. on the driving side to assist the riveter in driving the rivet stock squarely into the hole.

Samples of the later rivets driven showed uniform diameter and a bearing on the metal throughout.

Weight of Structure—The weights of metal in the various parts of the structure were approximately:

	Tons		Tons
Viaducts		**600-ft. Span**	
100-ft. girder spans	5,435	Trusses	4,365
Other girder spans	2,300	Floor	675
Cross girders	1,100	Bracing	410
Towers	5,115	Castings, rollers, etc.	160
Castings	465	Sheet lead	2
Railings	134		5,612
Sheet lead	21		
	14,570	Miscellaneous—Fences, cable supports, etc.	110
400-ft. Span		Total weight of metal	22,668
Trusses	1,650		
Floor	440		
Bracing	214		
Castings, rollers, etc.	70		
Sheet lead	2		
	2,376		

The weights of metal added to truss members for cantilever erection and included in weights given above, were 56 tons in the 400-ft. span and 162 tons in the 600-ft. span.

The total cost of the bridge, ready for service, was a little over $4,000,000.

Material—The material used throughout was open hearth structural steel having an ultimate strength of from 56,000 to 64,000 lb. per sq.in. with a yield point of 33,000 lb. per sq.in. for plates and shapes, and of from 46,000 lb. to 54,000 lb. with a yield point of 28,000 lb. for rivets. Consideration was given to the use of special steel, but no particular economy could be found at the unit stresses which would have been considered permissible. The use of special high-strength steel would have made the span of less mass and this was not considered a desirable feature.

Direction—The entire improvement was planned and carried out under the general direction of G. W. Kittredge, chief engineer, New York Central R.R., and J. W. Pfau, engineer of construction. W. F. Jordan, principal assistant engineer, was in direct charge of the field construction, with the late B. C. Martin, assistant engineer, succeeded by M. M. Manning assistant engineer in charge of the bridge construction.

The bridge was designed and the general detail drawings were prepared under the direction of the writer and Z. H. Sikes, assistant engineer of structures. The late Olaf Hoff, consulting engineer, checked and approved the design drawings and also acted in a consulting capacity in connection with the field operations. The general detail drawings were prepared under the immediate direction of J. E. Porter, assistant engineer for the superstructure, and F. R. Schmid, assistant engineer for the substructure.

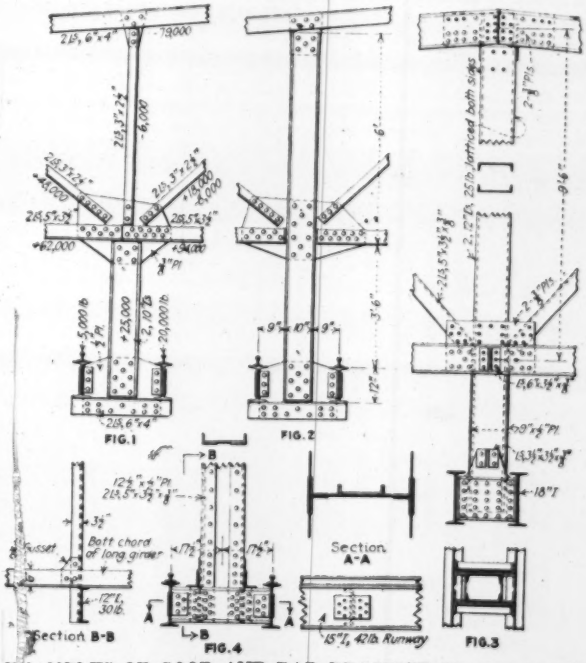
The steelwork was fabricated by the McClintic-Marshall Co. at their Rankin (Pa.) plant under the direction of G. L. Taylor, chief engineer, and was also erected by them. G. A. Caffal, manager of erection, and Jonathan Jones, assistant chief engineer, were in direct charge of field operations for them.

The west viaduct piers and the foundations for the west and center river piers were built by the Arthur McMullen Co. as subcontractors of the Walsh Construction Co., who built the rest of the substructures and the concrete deck.

A Recurring Fault in Detailing Crane-Run Hangers

By Robins Fleming
Structural Engineer, New York City

SOME faulty details of steelwork reappear in cycles. A crane or hoist runway suspended from the bottom chord of a roof truss furnishes an example; the fault is that the connection is apt to be detailed without proper provision for eccentric loading.



EXAMPLES OF GOOD AND BAD PRACTICE IN DETAILING CRANE-RUN HANGERS

Fig. 1—No provision made for transmitting eccentricity moment beyond bottom chord of truss. Fig. 2—Moment carried into truss frame by continuing hanger to top chord. Figs. 3 and 4—Connection of hangers to box-chord trusses in a large machine shop and in a brass-works building.

During the past 25 years the writer has periodically met a detail of which Fig. 1 is typical. The stresses in members adjoining the hanger are as indicated. The unbalanced vertical loading when but one crane is in action is 20,000 lb. The transverse horizontal thrust from the load moving on the bridge is 1,000 lb.

While the connection of runway beam to hanger is ample for eccentric loading the eccentricity at the top of the hanger and the bending in the bottom chord, more especially the latter, are neglected.

Fig. 2 shows how the requirements of both eccentricity and bending may be met. The bottom chord is spliced so as to allow the two-channel hanger to extend to the top chord. The hanger then acts as a lever.

Fig. 3 is a detail used for the box-chord trusses of a large machine shop built in 1902.

Fig. 4 is a detail used in 1906 for the box-chord trusses of a group of buildings.

Deep-Water Bridge Foundation of Concrete Pipe Piles

Special Methods Devised for Constructing Piers of Stockholm Harbor Bridge at Depths Up to 180 Feet

A REMARKABLE foundation was devised and successfully constructed for a large highway bridge over a branch of Stockholm Harbor, just completed and opened for traffic. The situation presented the combined difficulties of great water depth (60 to 65 ft.) and great depth of soft subsoil; rock lay at depths of 110 to 200 ft. below water level. A relatively thin layer of hard material, up to 25 ft. thick, overlay the rock, and above this level the ground did not furnish sufficient supporting power. Pneumatic foundations seemed out of the question, and a pontoon bridge was projected until the plan was presented which was later successfully executed and is here described. Its feature is the use of pipe piles of reinforced concrete, driven to firm bearing and filled with concrete after blowing out. These piles are 39 in. in outside diameter and were premolded in lengths up to 148 ft. They were driven in both vertical and battered positions. A ram weighing 10 tons was used for driving.

A second unusual feature of the work was precasting the pier shells, floating them over the piles, and then concreting the interior filling. Granite facing was cast in place in the shell before launching.

This foundation scheme was developed by Grün & Bilfinger, contractors, of Mannheim, Germany, and was offered by them (in conjunction with L. Eilers of Hanover for the superstructure) in a design-and-bid competition in 1921. Of 13 designs proposed in that competition, 12 projected a pontoon bridge, which had been stated by the owners to be the preferred type. The plan based on the tubular pile foundation was the only one for a fixed bridge, and it received the award.

Four years prior to this competition construction of a reinforced-concrete bridge at this point had been started, under a design providing for foundation on hollow reinforced-concrete piles closed at the bottom, to be driven to firm bearing. Little progress was made under this contract, however, due to war conditions and to doubts as to the feasibility of the contemplated construction. The contract was abrogated in 1920, and bids on a pontoon bridge were called for in the following year, with provision for alternate bids to other designs.

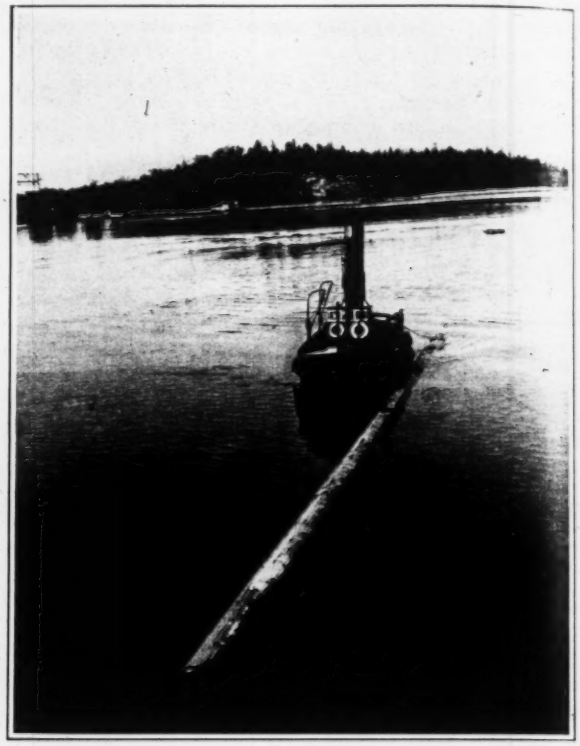


FIG. 1—FLOATING CONCRETE PIPE PILE TO PIER SITE

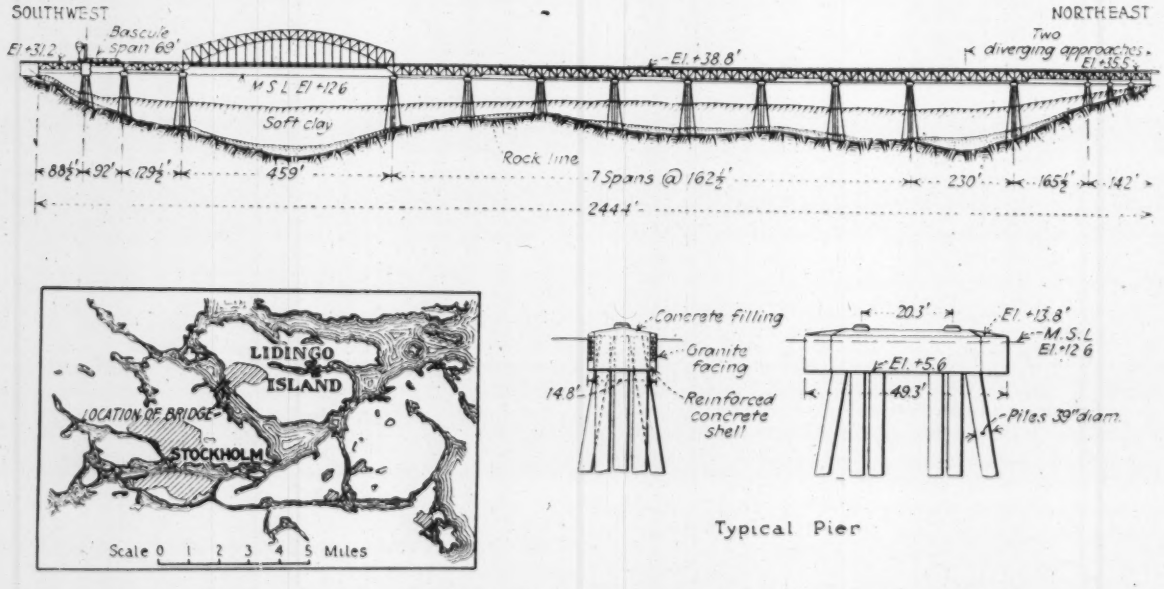


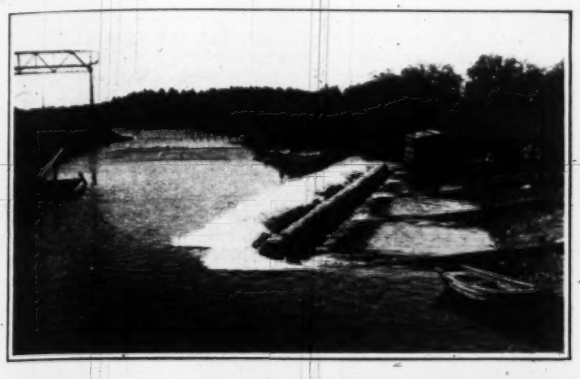
FIG. 2—LIDINGÖ ISLAND BRIDGE, STOCKHOLM, AND DETAIL OF CONCRETE PILE PIERS

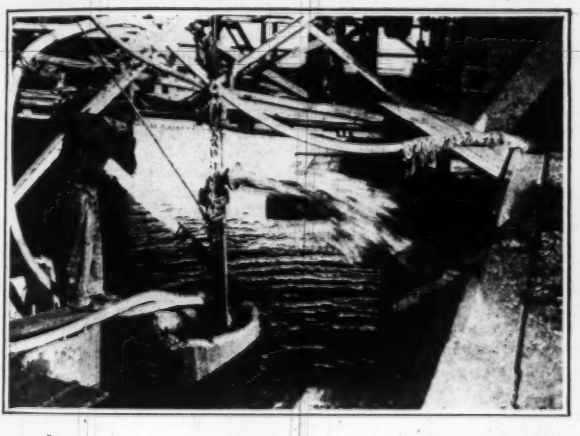
It was in this bidding that the executed design was submitted.

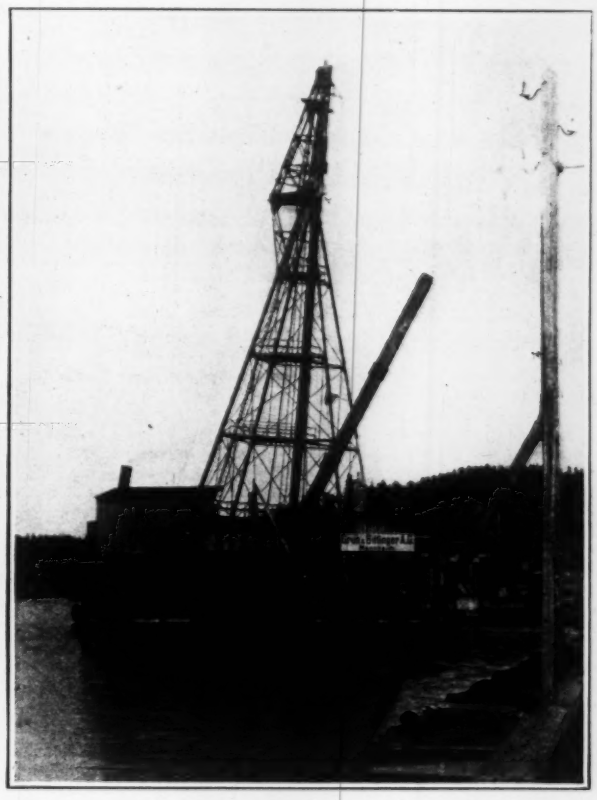
The structure and its location are shown in the drawing Fig. 2. The main span is a tied arch 459 ft. long between end pins, while the larger part of the crossing is made up of seven deck truss spans of 162½ ft. c. to c. of piers. The roadway is 22 ft. wide. The substructure comprises 17 piers and two abutments. At no less than 10 of the pier locations, the supporting stratum is more than 95 ft. below water.

as in timber trestle construction. The piers of the minor spans have 10 piles each, while those of the main span have 20 piles each.

Each pile is 39 in. in outer diameter, has a shell thickness of about 3 in. (8.5 cm.), and is a single piece for its full length (maximum 45 m. or 149 ft.), weighing up to 20 tons. The pile shells are reinforced with longitudinal rods and a spiral of 3-in. pitch. The piles were molded in horizontal position on shore, both ends being open; after setting they were bulkheaded at the ends and launched by rolling into the water. At the pier site they were lifted to upright position by a floating driver of height about 130 ft. above water. After being set in place (vertically or to the desired batter) they were driven through clay and gravel to firm bearing by a ram of 10 tons weight.







FIGS. 3-5—LAUNCHING, PLACING AND CLEANING OUT A PIPE PILE

Reference to Fig. 2 will also show the pier construction. Each pier consists of a shallow reinforced-concrete cap carried by a group of piles arranged somewhat

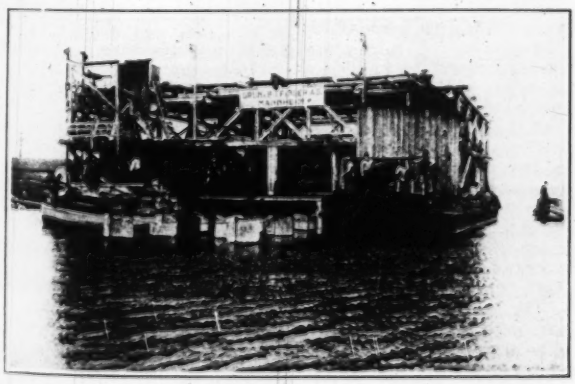


FIG. 6—FLOATING PRECAST PIER SHELL OVER PILES
Shell of reinforced concrete, with granite facing molded in place.

A total length of nearly 20,000 lin.ft. of pile was thus cast and driven. The material was of 1:1¾:1¾ mix, and showed a strength of 3,500 lb. per square inch in 28 days.

When the piles were down to firm bearing they were cleaned out by an air ejector, which excavated a depth of 60 to 65 ft. in an 8-hr. shift. They were then filled with 1:4 concrete, placed under water by means of a specially designed bucket of about ¾-cu.yd. capacity. Concreting was continued to within 3 ft. of final pier top, and the shell was cut off at this point, leaving sufficient longitudinal reinforcing to tie into the pier concrete.

The piers were constructed by placing and filling a precast shell. These shells were cast on land, the

granite facing being molded in place. After setting, they were transported on a platform between two scows to the pier site, and were then lowered down to wooden platforms fastened to the piles 8 ft. below water level. A 2-ft. seal course of concrete was placed in the shell, under water, and, after this had set, the water was pumped out and the remainder of the pier core concreted in the dry. The bridgeseat blocks were also cast of reinforced concrete.

Foundation construction began in the spring of 1922 and was completed before the end of 1923, without incident. Since that time the superstructure has been completed and the bridge is about to be opened for traffic.

Brass and Copper Pipe for Water Services and Plumbing

Manufacturer's Claims for Advantages and Economies Presented—Agreement and Dissent Brought Out in the Discussion

BY W. G. SCHNEIDER

Research Department, Copper and Brass Research Association, New York City

Abstract of a paper and discussion before New York Section, American Water Works Association, March 26.

PIPES of copper are the oldest pipes we know of. A piece of copper pipe, 5,400 years old, is on display at the office of the Copper & Brass Research Association. The pipe was unearthed at Ghizeh, near the tomb of the Egyptian King Sahoure, and is believed by Egyptologists to be 5,400 years old. Brass, a copper alloy, has been used for many years for pipe. The Parker House, Boston, erected in 1856, has brass pipe that has given 67 years of service without a leak. Within our own times the extensive use of brass and copper for water service piping has just started but those vitally concerned are more and more coming to appreciate its value.

Red Water—Probably everybody has, at one time or another, turned on the faucet and seen a stream of dirty red rust-colored water issue therefrom. This red water nuisance is due entirely to the use of ferrous or corrodible pipe or other ferrous products such as tanks. This rust is sure to stain expensive white enamel fixtures, possibly on wash day ruin the clothes, not to mention the temper of the housewife. Red rust is iron oxide and is certain to form wherever iron, such as is used for piping, is exposed to water and air. Brass or copper pipe avoid the red rusty water nuisance and while the comfort and convenience, as well as the sanitary aspect of their use on this account, is hard to measure in dollars and cents, it is nevertheless very real and should not be overlooked.

A 1-in. iron pipe is completely rust clogged when one-fortieth of its wall thickness is converted into rust. Inasmuch as brass or copper do not rust and do not become rust clogged, it is possible to use a smaller sized pipe as compared to the necessary size of pipes that rust. In hot water lines a ½-in. brass pipe will do the work of a ¾- or of a 1-in. pipe, and so on until we find that a 2-in. brass pipe will serve in place of a 3-in. iron pipe. For cold water a ½-in. brass pipe will do the work of a ¾-in. iron, a ¾-in. of a 1-in. and so on until a 2-in. brass pipe may be used in place of a 2½-in. iron. In branch lines, both hot and cold, ⅜-in. brass pipe will do the work of ½-in. iron.

Wiped joints nowadays mean a high labor cost and skilled help. Special joints with a breakable material are as a rule difficult to make and to maintain. Brass pipe enjoys an advantage over copper in this respect as it is easier to thread. In fact it is just as easy for a good workman to install brass as galvanized pipe. The same dies that thread the galvanized pipe may be used for threading brass pipe.

Simple Rules—The following ten simple rules are the practice of good plumbers:

1. Use only good brass fittings with threads of standard gage and size. Do not use iron fittings on a brass pipe job.
2. Cut the pipe with your regular cutters or with a hack saw. Ream the pipe to remove all burrs.
3. Use good dies without broken teeth.
4. One-quarter inch per 10 ft. of length is ample allowance for expansion for hot and cold water lines.
5. When threading keep the pipe as near to the vise as is consistent with easy working.
6. While a lubricant is not absolutely necessary, it facilitates threading.
7. With properly made dies run the die onto the pipe until its surface is just flush with the pipe. When such threaded pipe is screwed home in the fitting no threads will show.
8. Use care in threading and cut the threads down to exactly standard gage and size.
9. Best appearance in the finished job is obtained by using friction jaws in the vise and friction wrenches. Use care if you screw brass pipe home with a stillson wrench so as not to mar it unduly.
10. With careful threading, good fittings and proper screwing home, no pipe "dope" is necessary. Wicking is recommended as preferable to a paste of ground red lead and glycerine, or red lead and linseed oil.

Relative Costs—The price, as published, of various standard piping materials, 1-in. size, is as follows: Galvanized steel, 10½c.; genuine wrought-iron, 14¾c.; galvanized genuine wrought iron, 18½c.; brass pipe, 40c.; copper pipe, 44½c.; lead pipe (1A—4 lb. per ft.), 48c.; but inasmuch as corrodible pipe materials soon become badly coated with rust and rust clogged, it is necessary to use 1¼- instead of 1-in. steel and wrought-iron pipe, which brings up the cost for these three materials, as follows: Galvanized steel, 14c.; genuine wrought iron, 20c.; galvanized genuine wrought iron, 25 cents per foot.

The total cost of any installation is made up of material, labor and fixed charges. Every one knows that so far as installations of plumbing or service pipe are concerned the cost of the pipe is a minor item as compared to all other charges. The labor charge on the other hand is very large compared to the cost of the pipe. On this basis alone we should select the very best pipe obtainable, provided it is possible to install it on a basis comparable with the cost of installing an inferior pipe. Of the materials listed above, lead is the most costly to install, and requires more or less skilled labor. Brass and copper have all of the advantages of lead and none of its disadvantages.

How long brass or copper will last cannot definitely be stated, but plumbing installations made in 1865—60 years ago—are still going strong. If we assume the service pipe installation of 50 ft. where the charges, excluding the pipe and connection to main, are $1.50 per ft. (this may vary according to best advice, from 75c. to $4) we have:

	Galv. Steel	Black g.w.i.	Galv. g.w.i.	Brass	Copper	Lead
Pipe	$7.00	$10.00	$12.50	$20.00	$22.25	$24.00
Labor and other charges	75.00	75.00	75.00	75.00	75.00	75.00
	$82.00	$85.00	$87.00	$95.00	$97.25	$99.00

With only one replacement cost at the end of say five years in the case of corrodible pipe, the economy of brass or copper is apparent. But when we figure not only the replacement cost but also other expenses, there are fundamental reasons why brass or copper are the best materials for plumbing or service piping.

Discussion—A representative of manufacturers of steel pipe expressed the opinion that the comparative cost figures for brass and iron or steel pipe given by Mr. Schneider were misleading. He urged that $100 invested in galvanized steel pipe should be compared with $350 for brass pipe to do the same work and that figuring compound interest on the investment the steel pipe would be the more economical. He also said that brass pipe at East Providence, R. I., had given trouble and that in other cases the life of brass pipe had been only 5 to 8 years. He suggested that where water is corrosive, a de-aeration plant should be installed to remove dissolved oxygen and thus prevent corrosion.

Mr. Schneider replied that a survey of 128 apartment houses in Pittsburgh where genuine wrought-iron pipe had been used showed trouble in this pipe after 4 years, while after 9 years all the steel pipe used had failed and after 14 years all but one of the genuine wrought-iron pipe installations had failed, whereas at the end of 18 years there had been no failure of brass pipe recorded.

J. W. Ackerman, city manager, Watertown, N. Y., speaking of difficulties in service pipes carrying water from

peaty gathering grounds, and subjected to pollution, said that after filters were installed there were serious red water troubles. Almost everything had been tried to obviate the troubles, including an aeration plant, and the use of cement-lined pipe, among other materials. Iron pipe does not last at all and brass does not stand the water. Copper tubing is to be given a trial.

Question having been raised as to the composition of brass pipe, Mr. Schneider said that for hot water pipes used for many years in hotels in Atlantic City, N. J., government specifications calling for 70 per cent copper, 29 per cent zinc, and 1 per cent tin, had been used. Over the country generally a 60 per cent copper and 40 per cent zinc mixture had given good results. Answering a further question as to special fittings and electrolysis, Mr. Schneider said that there had been little trouble with electrolysis, because there is no great difference in the composition of the material for the pipe and the fittings. Continuing his answers to questions, Mr. Schneider said that years ago there used to be cracking in brass pipe, but this no longer occurs because now brass pipe is semi-annealed.

W. W. Brush, deputy chief engineer, Bureau of Water Supply, New York City, and Dr. Frank E. Hale, director of water laboratories, New York City, both cited instances of blue discoloration of wash bowls or other plumbing fixtures supplied by brass pipe and even from a brass faucet supplied by an iron pipe. Dr. Hale said that the blue discoloration was heaviest on the higher floors of buildings, and that there had been complaints from various sources against brass and copper pipe where used for different purposes. Mr. Schneider said that blue discoloration was exceptional. Mr. Brush mildly characterized Mr. Schneider's paper as an instance of special pleading for a given material and suggested that the chemists of the various water departments of the country study the questions.

D. W. French, superintendent, Hackensack Water Co., Weehawken, N. J., said that 25 years ago a lot of brass pipe was put in at the main pumping station of his company for boiler feed and other purposes. It is still in use and there has been no trouble from leaks or otherwise. More or less trouble has been experienced with both lead and iron pipe. Owing to the failure of ⅝-in. lead services to deliver sufficient water, ¾-in. lead is now being used. The earliest brass pipe used was unannealed. It broke. In 1924 the company began buying semi-annealed brass pipe and has had no trouble with it. Brass pipe for the year 1925 is being bought on the specifications of the American Society for Testing Materials. Finally Mr. French said that brass is proving to be much cheaper than lead; that ¾-in. brass pipe is being used; and that the company believes that in continuing to use brass pipe it is on the right track.

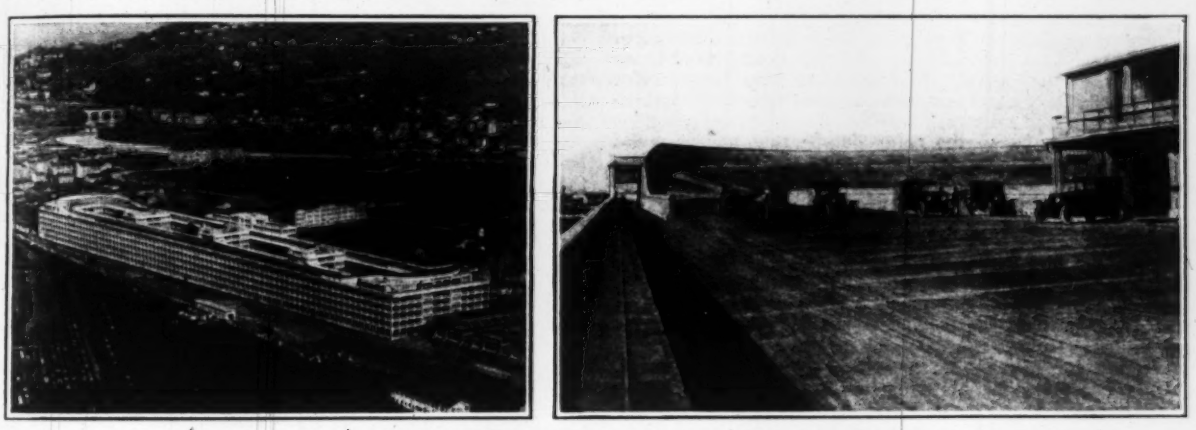
Congressmen to Visit Reclamation Projects

During the recess of Congress a sub-committee of the appropriations committee of the House of Representatives will visit several of the national parks and reclamation projects. Representative Cramton of Michigan is chairman of the sub-committee.

Automobiles Tested on Roof Track of Factory

TO PROVIDE for running tests of finished automobiles before shipment, the new Fiat automobile plant at Turin, Italy, has a testing track on the roof of the main shop building. Because of the large size of the building it was possible to make this testing track more than 1 km. long, and by banking the turns heavily the track was made suitable for very high speed. Convenience and economy are gained over the former practice of making road tests outside of the factory. A much smaller number of test drivers is required, the loss of time in going to or from the test road is saved, and the entire testing process is more thorough and is better integrated with the general inspection system. The track accommodates a large output of machines.

Because of the layout of the factory building, consisting of two very long parallel aisles connected by two end and three intermediate wings, a track arranged somewhat like an ordinary racetrack could be laid out without difficulty. The transverse wings contain elevators, 17 in all, by which the cars are brought to and from the track. Inspection and supervisory quarters are placed under the banks of the turns.



FIAT WORKS AT TURIN HAVE HIGH-SPEED TESTING TRACK ON ROOF

The track has a length of slightly over 1 km. (⅝ mile). It is 24 m. (78 ft.) wide on the straight, while the turns, of 20 m. (66 ft.) inside radius, are 15½ m. (51 ft.) wide in horizontal projection. The structure of the track is reinforced concrete, and the surfacing is asphalt, 2 to 2½ in. thick. Transversely, the roadway is crowned 16 in. on the tangents, for drainage. The turns are banked 6 m. (20 ft.) and have a hollow profile, with cross-slope ranging from 0.35 to 0.50 from inner to outer edge. Snow is disposed of by melting, steam pipes being laid in the track for this purpose. The parapet wall of the track is generally 5 ft. high, but on the outside of the turns it is 10 ft. high.

Provision is made at the lateral approaches to the track, alongside the elevator towers, for gasoline, oil, water, and compressed air supply, and for electric starting current. Gasoline is supplied from storage tanks outside the building, by a pipe supply system, and after working hours all gasoline is drained back to the tanks so that none remains in the building. In cold weather oil and water are heated by steam or electricity.

In regular operation each chassis is put through two running tests on this track, by different drivers, each making an independent inspection report. After body and equipment are fitted, another running test is made.

Letters to the Editor

This department aims to be a forum for the discussion of the views of engineers and contractors. The range of interest should be as wide as possible. Contributors are, therefore, asked to make their letters short.

Milton H. Freeman

Sir—The death on March 24 of Milton H. Freeman, chief engineer of the Holland Tunnel, now being constructed under the Hudson River, between Manhattan and Jersey City, coming so soon after the death of his predecessor, Clifford M. Holland, imposes a loss on the New York Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission, under whose supervision this great work is being done, and calls attention to the sacrifices that are made by conscientious men to tasks which are entrusted to them in the interest of the public, and of the advancement of the construction art.

It was my privilege to have been associated for many years with Mr. Holland and Mr. Freeman, and to have enjoyed the friendship. While they were men of different personal characteristics, both were fundamentally the same in their conscientious devotion to their duty. It is due to Mr. Holland's genius that the vehicular tunnel that bears his name has been advanced so far on its way to successful completion. Mr. Freeman was his able lieutenant, working modestly and quietly, studying under the direction of his chief every one of the many details that made up the work. Perhaps his modesty was carried too far, because few outside of his associates knew of his ability and his absolute reliability. Mr. Holland used to say of him that he was an engineer who made the reputations of other engineers.

I first met Mr. Freeman on the construction of the Catskill Aqueduct, when he was assigned as an assistant engineer to one of the most difficult sections of construction of that great project, the deep pressure tunnel under Rondout Valley. He worked day and night on this work with no regard for hours. As a matter of fact, it was frequently necessary for his superiors to order him home to rest. No detail of the construction escaped his attention and his constant aim was to improve the quality and raise the standard of the work. Later, for a number of years, he was engaged, under Mr. Holland's direction, on the construction of the rapid-transit tunnels under the East River where he showed the same devotion to his work, never sparing himself. It was his custom to stay on the job and sleep in the field office whenever anything appeared to be wrong on the work under his charge.

The following incident of his devotion to duty may be cited: Certain leaks had developed in the subway station under Canal St. in Manhattan, and it was decided to stop them by grouting the walls and roof. Mr. Freeman was called upon to take charge of the work, his knowledge of grouting gained on the construction of the Catskill Aqueduct fitting him for the task. The work was carried out most successfully, due largely to his personal attention. One day on my visit to the work the inspector came to me and said that he could not understand Mr. Freeman, that the day before he had spent 15 hours on the platform of the station supervising some important feature of the work without going to the street for food and that the inspector had brought sandwiches to him to keep him from starving. Mr. Freeman did not speak to me of this incident, but I know it is true, and it is an indication of his conscientious feeling toward anything he was given to do.

This tribute of appreciation is due Mr. Freeman. Those who were associated with him knew of his sterling worth, and it is well that his profession generally and the public he served so faithfully should also have some knowledge of the faithfulness with which he served.

ROBERT RIDGWAY,
Chief Engineer, Board of Transportation,
New York City, City of New York.
March 27, 1925.

Asphyxiation Due to Oxygen Depletion

Sir—The accident at Columbus, Ohio, resulting in the death of four men, recorded in *Engineering News-Record*, Feb. 5, 1925, p. 249, is somewhat similar to one which occurred at Tulsa, Okla., Sept. 12, 1923.

Two engineers employed on the Spavinaw water project went into a concrete chamber, 6 ft. square and 35 ft. deep, to make certain measurements. The chamber had a single opening 3 ft. square located at the top. A concrete slab, 8 ft. below the top of the chamber and extending across two-thirds of the cross-section, restricted ventilation. Access was by iron manhole steps. Almost immediately on reaching the bottom of the chamber and without speaking a word, one of the men collapsed. The other felt no ill effects until he had climbed nearly to the top of the chamber, although he had spent probably three minutes in an ineffectual attempt to carry his comrade up the ladder. Several men were successively let down with ropes in attempts to remove the unconscious man, but none were able to remain sufficiently long to tie a rope about him until an oxygen mask was procured. The man was dead when brought to the top of the chamber.

Analysis of air samples taken later in the day showed insufficient oxygen to support life, and further, the ratio of oxygen and carbon-dioxide contents was exactly as would occur from the consumption of oxygen and production of carbon dioxide in normal respiration. No foreign gases were found. The apparent explanation for this condition is as follows: On the third day previous to the accident, three men had worked all day in the chamber stripping and removing forms from the wall faces. On the next day three other men were in the chamber five hours completing this work. The day previous to the accident no one was in the chamber. The 3x3-ft. opening at the top was kept covered except when the men were working inside. It is believed that these workmen used up the greater part of the oxygen in the chamber air, which was not replenished from the outside air, and that during the day, intervening between completion of the form stripping and accident, the heavier carbon dioxide content settled to the bottom of the chamber. All of the men who had worked on the form stripping stated they had noticed nothing unusual in the air conditions, which may be explained by the fact that their presence and movements kept the air sufficiently stirred and mixed so that, though deficient in oxygen, there was no marked separation and settling of the carbon dioxide.

In a case such as this, we are apt to consider the previous safe entry of a man, barring a change in external conditions, a criterion of our own safety. This particular instance illustrates how previous occupation may in fact be a source of danger.

F. H. HOLWAY,
Tulsa, Okla., Holway Engineering Co.
March 20, 1925.

"Selecting New Americans"

Sir—Permit me to comment on your editorial of March 19, "Selecting New Americans."

Granted the necessity of selecting our immigration in accordance with our needs; the question to be decided is whether our selection shall be based on our present or on our future needs. Your editorial stresses the former. I wish to call your attention to the latter.

My view is that our industrial supremacy is more dependent upon the intelligence of our leaders than upon the brawn and manual skill of the tradesman. Therefore the most desirable citizen from an industrial standpoint is the scientist, the engineer, the executive.

The same issue of *Engineering News-Record* speaks in praise of John F. Hayford, Charles P. Steinmetz, Dr. Osler, and Pasteur. Compare any one of these with the importance of a thousand puddlers to our civilization. The latter may satisfy an urgent need of the present, but what assurance have we that their children, laboring under the handicap of mediocrity, will not increase the barber and waiter class?

An immigrant should, by all means, be possessed of sufficient training and skill to become himself a useful citizen. However, in behalf of future Americans who will descend from him, it is more important that he be equipped with an intelligence equal to, or, preferably, higher than the average of our present citizenship.

ALVAN TALLMADGE,
Columbus, Ohio, March 23, 1925. Structural Engineer.

News of the Week

CURRENT EVENTS IN THE CIVIL ENGINEERING AND CONTRACTING FIELDS

Court Opinion Keeps Keystone Co. From Subway Contract

In an opinion handed down on March 31, Justice McDevitt, sitting in Common Pleas Court, Philadelphia, granted an injunction based upon a taxpayer's suit restraining the Keystone State Construction Co. from receiving the award of the contract for a portion of the Broad St. subway. (See *Engineering News-Record* of March 26, p. 537, for details of the suit.)

In his opinion Justice McDevitt asserted that "It would be unfortunate if the law were so inelastic that regulations made for the protection of the city could be evoked to deprive it of a right to make a contract in all respects beneficial where every right will be protected. The check shortage is not such a defect as would injure either the city or other contractors, but such as might be waived in the interests of the public welfare."

J. R. Enbery, counsel for the Keystone State Construction Co., has filed notice of an appeal.

Power Commission Secretary Comments on Conowingo

Washington Correspondence

Discussing the objections raised by the state of Maryland to the development of power within the state for export to Pennsylvania, O. C. Merrill, executive secretary of the Federal Power Commission, says that for Maryland to reserve the right to recall power exported from the state in connection with the proposed development at Conowingo on the Susquehanna River probably would have the effect of preventing the development of the project by those now proposing to undertake it.

"I know of no cases," says Mr. Merrill, "where these questions with respect to interstate power transmission have been decided definitely, but analogous cases of interstate wholesaling of natural gas cast considerable doubt on the exercise of such power by the states."

Construction Firm Wins Verdict Against City of New York

Trial of an action instituted by the receiver of the Bradley Construction Co. against the city of New York for $687,000 before Federal Judge Thomas E. Thacher and a jury ended March 24, when a verdict for the plaintiff of $102,500 plus about $40,000 interest was rendered. The action grew out of a contract awarded the company in 1911 for construction of part of the Lexington Ave. subway at a contract price near $4,000,000. It was alleged that because of the city's delay in supplying plans of changes the work was increased by the amount named in the suit.

Engineering Fifty Years Ago

From *Engineering News*, April, 1875

COAL in the United States — The production of anthracite coal in the United States is now estimated at 19,000,000 tons per annum. The production has generally doubled every ten years, so that by 1884 it is expected that it will not far short of 40,000,000 tons per annum.

Contract Awarded on Oakland Estuary Tunnel

Bids were opened on March 23 on the tunnel to be built under the estuary between Oakland and Alameda, Calif., and on the same day contract was awarded to the A. J. Crocker Co. of San Francisco for a total price of $3,882,958.40. The contract allows a construction period of 900 days from date of signing the contract. A description of this tunnel and the proposed method of construction, which involves the casting of concrete sections of the tube on shore and floating them to place, appeared in *Engineering News-Record*, Oct. 30, 1924, p. 720.

One other bid, in addition to that whose amount is mentioned above, was received. The Healy-Tibbitts Construction Co. submitted a figure of $5,151,780. Both bidders put up certified checks for $150,000 with their bids.

Services and Plumbing Discussed by N. Y. Section, A.W.W.A.

At the closing meeting last week of the 1924-25 season of the New York Section of the American Water Works Association the topic for discussion was brass and copper pipe for services and for house plumbing. The subject was presented by W. G. Schneider, of the Copper & Brass Research Bureau, New York City. An abstract of the paper and ensuing discussion is given elsewhere in this issue. As governor for 1925-26, the section elected E. D. Case, vice-president, the Pitometer Co., New York City.

Albany Port Commission Named

Governor Smith of New York has named the following four port commissioners for the newly-created Albany Port District: Alfred J. Kaufman, city engineer of Rensselaer; Frank C. Herrick, a merchant of Albany; Thomas Fitzgerald, former deputy city and state controller; and Albert E. Dale, city editor of the Albany *Evening News*. The fifth member will be named at a later date.

Nickel Plate Merger Opposition Gains Delay in Virginia

The stockholders' protective committee of the Chesapeake & Ohio Ry. Co. gained a point in their opposition to the 999-year lease of the railway to the new Nickel Plate System, when Judge Moncure in chancery court in Richmond, Va., ruled that the proposed lease must not be executed until the court definitely decided whether the railway company has power under the Virginia statutes to enter into such an agreement, even though the Interstate Commerce Commission may approve of the lease. In this ruling the judge declared that he believed the court rather than the Interstate Commerce Commission has prior jurisdiction in deciding as to the validity of the lease.

It will probably be some weeks before Judge Moncure has completed his study of the case and rendered his decision.

U. of Illinois Given Painting of Prof. Talbot

A portrait painting of Professor A. N. Talbot was presented to the University of Illinois at an assembly of the college of engineering of that institution, March 27. The painting was given to the university by the alumni and faculty and by engineers who have been closely associated with Prof. Talbot in his work in the American Society of Civil Engineers, the American Society for Testing Materials and the American Railway Engineering Association.

The presentation address was made by W. L. Abbott, chief operating engineer of the Commonwealth Edison Co., Chicago, and the formal address, on "The True Measure of Engineering Achievement," by Edward J. Mehren, vice-president, McGraw-Hill Co., New York.

At the same meeting a bronze plaque accompanied by resolutions from the American Railway Engineering Association, expressing its appreciation of his contribution to railway engineering science, was presented to Prof. Talbot.

Canadian Pacific Plans 215 Miles of Extensions

Six extensions which the Canadian Pacific Ry. proposes to build this year include the Langdon north branch line, part of which will be used jointly by the Canadian National Rys., which will pay half the cost. The extensions are as follows: Cutknife-Whitford Lake branch, 55 miles; Amulet-Dunkirk branch, 20 miles; connecting Pashley Northeastern branch with Leader Southern branch, 33 miles; extending Pashley branch to Fox Valley, 25 miles; connecting Fife Lake branch with Moose Jaw branch, 43 miles; extending Langdon branch, 39 miles.

Record-Breaking Attendance at Sewage Association

Hundred Men from New Jersey and Other States Hear Papers—Will Not Take National Name

Engineering News-Record Staff Report

A record-breaking attendance of well toward a hundred, including engineers from New York, Philadelphia, Boston and Cleveland; five papers; a luncheon and re-election of most of the current officials marked the annual meeting of the New Jersey Sewage Works Association, held at Trenton March 27. It was announced during the meeting that Dorr Co., New York City, has established a $2,000 one-year fellowship at the New Jersey sewage substation for studies of general interest proposed by the company, also that some $2,000 of Imhoff tank patent royalties will probably be assigned by the Chemical Foundation for equal division between the substation and the engineering department of the University of Illinois. A report adverse to changing the name of the association to one of national scope was adopted but the resolution extended a welcome to members from all over the country.

Papers Read

Increased use of (1) glass-covered drying beds for Imhoff tank sludge, and (2) of separate sludge digestion for both Imhoff and activated sludge were brought out in a paper by Weston Gavett, consulting engineer, New York City, and the resulting discussion.

Licensing sewage-works operators in New Jersey under the legislative act of 1918 was the subject of a paper by H. P. Croft, chief engineer, New Jersey Department of Health. Four classes of licenses are issued by the department after examination and certification by a special board of examiners.

Repairs to a break in the Montclair-Bloomfield 24-in. vitrified pipe outlet, 20 ft. underground, were described in a paper by Paul Molitor, of Chatham, who was called in by Clyde Potts to assist on the work. In some stretches the sewer, which apparently had been under pressure for ten years, showed top and bottom cracks, without distortion, and in other stretches cracks at all four quadrants, with distortion, while about 30 ft. of it was broken in. A considerable length was rebuilt, but a 40-ft. length of the sewer, before Mr. Molitor took hold, was lined with a $\frac{1}{4}$-in. steel plate.

Compulsory monthly reports by sewage-works operators to the New Jersey Department of Health were described by Charles Nichols, of the department's engineering staff. The record is of value to the operator as well as to the municipality and the public, since it shows the difficulties the operator encounters. The most important items on the monthly reports are the weir and the methylene blue or effluent stability readings.

The year's work at the sewage substation conducted under a joint state appropriation to the New Jersey Agricultural Experiment Station and the State Department of Health was reviewed, as at previous yearly meetings, by Dr. Rudolfs, chief of the laboratory, New Brunswick. Besides the regular studies at the Plainfield sewage-works (Imhoff tanks and sprinkling filters) the substation has been co-operating with eight or nine sewage-works in a study of pH concentration. Much attention has been given to protozoa in sewage, which, it is found, play a more important part in Imhoff tanks than was formerly supposed. From correspondence it appears that the more usual and numerous kinds of protozoa are common to the sewage of cities as widely apart as Plainfield, N. J., Everett, Wis., and Moscow, Russia.

Two Engineers Are on Muscle Shoals Commission

Washington Correspondence

John C. McKenzie, a former member of Congress from Illinois, will head the President's commission which is "to examine into and report to him upon the most practical method or methods of utilizing to the best advantage the Muscle Shoals facilities." The other members selected by the President to serve on the commission are: Nathaniel B. Dial, formerly a senator from South Carolina; Prof. Harry A. Curtis, of Yale University; William McClellan of New York, and Russell F. Bower of the American Farm Bureau Federation.

Chairman McKenzie represented the thirteenth Illinois district in the House of Representatives from March 4, 1919 to March 4, 1925. Mr. Curtis is professor of chemical engineering at Yale University. He was consultant to the Department of Agriculture in the reorganization of its fertilizer work and was at one time executive officer of the nitrogen research office under the United States Army. He directed the recent world nitrogen survey of the Department of Commerce. Mr. Curtis holds degrees from the University of Colorado and University of Wisconsin.

Mr. McClellan, an electrical engineer, is a graduate of the University of Pennsylvania, and was at one time dean of the Wharton School at that university. He is a past-president of the American Institute of Electrical Engineers and has had large experience in construction and operation of electrical equipment.

Smith Signs Three Bridge Bills of New York

Governor Smith of New York has signed bills passed by the legislature just before its adjournment making available funds for the construction by the Port Authority of bridges between New York and New Jersey across the Arthur Kill and the Hudson River. By the terms of the acts $400,000 is appropriated yearly for five years for each of the two Arthur Kill bridges, and $100,000 is made available for preliminary engineering studies on the Hudson River structure. The latter it is proposed to erect between the Jersey shore and Manhattan at a point between 175th and 185th Sts., Manhattan. New Jersey has already passed similar legislation.

New Action on Colorado River Compact

Upper Basin Legislatures Ratify Six-State Agreement While Arizona Ratifies with Reservation

Resolutions converting the seven-state Colorado River Compact formulated in 1922 and subsequently ratified by six of the seven basin states (Arizona alone refusing to ratify) have been passed by three of the upper-basin states and by the lower house of the California Legislature. The resolutions recite:

"That the provisions of the first paragraph of Article XI of the Colorado River Compact, making said compact effective when it shall have been approved by the legislature of each of the signatory states, are hereby waived and said compact shall become binding and obligatory upon the state of Colorado and upon the other signatory states, which have ratified or may hereafter ratify it, whenever at least six of the signatory states shall have consented thereto and the Congress of the United States shall have given its consent and approval;

"*Provided, however*, that this resolution shall be of no force or effect until this or a similar set of resolutions shall have been passed or adopted by the legislatures of the states of California, Colorado, Nevada, New Mexico, Utah and Wyoming."

It has been approved by Colorado, Wyoming and Utah. The California bill makes approval contingent upon prior provision of 20,000,000 acre-ft. storage by the federal government.

Arizona's Action

In Arizona the legislature has passed a contingent ratification of the original compact. The ratification is not to be effective until California, Nevada and the United States approve an agreement with Arizona as to the apportionment of the lower-basin allotment; such approval must be given by California and Nevada by March 15, 1927. The apportionment proposed by Arizona is included in the resolution of the Arizona Legislature. It gives to Nevada "all of the water which can reasonably be applied within said state to domestic and agricultural uses."

California and Arizona are then to share equally in the 7½ million acre-ft. per year allotted to the lower basin by the original compact, but the additional 1,000,000 acre-ft. given the lower basin is to belong exclusively to the state of Arizona; provided, that said right shall attach solely to and shall be held to completely exhaust the right to the use of waters of the Colorado River system entering the Colorado River within the state of Arizona below Lee's Ferry.

Further, any supply that may be allotted to Mexico, so far as it is to be contributed by upper and lower basins under the terms of the original compact, is to be taken out of the 7½ million acre-ft. allotment and not out of the last-mentioned addition.

Governor Hunt has vetoed the above mentioned resolution passed by the Arizona Legislature.

Milton H. Freeman, Holland Tunnel Engineer, Dead

Successor to Late Clifford M. Holland Succumbs to Pneumonia Caused By Overwork

Milton H. Freeman, who succeeded the late Clifford M. Holland as chief engineer of the New York & New Jersey Bridge & Tunnel Commission, in charge of construction of the Hudson River vehicle tunnel, died of pneumonia on March 24 at his home in Valhalla, N. Y. Long-continued overwork, due to conscientious devotion to his duties, had weakened his resistance to disease.

Mr. Freeman had a notable career, most of it on New York public works. Born at Crary Mills, St. Lawrence County, N. Y., on Oct. 12, 1871, he took up teaching when he graduated from Potsdam Normal School, but after four years in teaching he entered the University of Michigan in 1899. His original purpose of specializing in mathematics and physics then changed in favor of civil engineering, which thenceforward was his life work. Upon graduation he served two years with the Michigan Central R.R. and then came to New York in 1905.

His first work here in the professional field which was the scene of his future activities was on the Pennsylvania East River tunnels, where he put in four years as inspector and assistant engineer on the shield tunnel driving. Then he joined the Catskill Aqueduct organization of the Board of Water Supply, and for most of the next five years was field engineer on the difficult Rondout Siphon tunnel, much of the time in charge of concrete lining and high-pressure grouting. During this period he made a marked success in concrete construction and grouting. The latter particularly was there developed to an effectiveness not previously attained.

In 1919 Freeman became resident engineer on the Old Slip rapid-transit tunnel under the East River, part of the extensive subway construction work then being carried out by the Public Service Commission. C. M. Holland was in charge of the tunnel work, and the successful and rapid progress of the difficult enterprise was largely due to the brilliant direction and watchful care which he and his staff gave to it. Freeman later took charge of the river section of the 60th St. rapid-transit tunnel and of shaft work on the 14th St. tunnel.

Shortly afterward it became necessary to correct extensive leakage of the Canal St. station structure of the Broadway subway. After various methods had been considered, grouting was decided on as most promising, although it was doubted whether full success could be attained. The work was delicate and required an exceptional combination of experience, intuitive understanding of local factors and the ability to work out an operation step by step. Because of his work on the Catskill aqueduct Freeman was selected to carry out this work. It was completely successful, largely because of the same unremitting attention to detail and thorough study that had characterized all his previous work. His own description of the operation (*Engineering News-Record*, Aug. 12, 1920, p. 314) is an excellent record.

When construction of the Hudson River vehicle tunnel was undertaken in 1919, Holland as chief engineer chose Freeman with Jesse B. Snow, now engineer of the Narrows tunnel, and Ole Singstad, engineer of design of the Hudson River tunnel, in the first small group of his lieutenants. Following the study and design period, in 1920 Freeman took charge of field operations, continuing as engineer of construction through the whole time of shaft sinking and tunnel driving. The many new problems presented by the construction of the pair of 30-ft. tunnels through the soft soil of the Hudson River crossing depended in the first instance on him for their correct and sound solution.

Upon the sudden death of Holland, his chief, last October, Freeman was chosen by the commission to fill the vacant position of chief engineer. Officially appointed to the position on Dec. 1, he held it less than four months.

Freeman combined in remarkable manner the qualities of the student and those of the construction engineer. His habit of analyzing painstakingly and thoroughly every problem put before him was early recognized, and his thoroughness came to be depended on by his superiors. Both in study and in field supervision, however, he spared himself less than others, and this is largely responsible for his premature death.

Robert Ridgway, chief engineer of the Board of Transportation, New York City, who was his chief during the Catskill aqueduct and Public Service Commission period, gives a personal appreciation of Mr. Freeman's achievements and qualities on another page.

Engineering Societies

Calendar

Annual Meetings

AMERICAN WELDING SOCIETY, New York City; Annual Meeting, New York City, April 22-24, 1925.

AMERICAN WATER WORKS ASSOCIATION, New York City; Annual Convention, Louisville, Ky., April 27 to May 2, 1925.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston, Mass.; Annual Convention, Chicago, May 12-14, 1925.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago, Ill.; Annual Convention, Orlando, Fla., June 2-5, 1925.

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia, Pa.; Annual Meeting, Atlantic City, N. J., June 22-26, 1925.

Personal Notes

GEN. JAY J. MORROW, governor of Panama Canal Zone from 1921 to 1924, has been appointed by President Coolidge as a member of the Tacna-Arica Boundary Commission, of which Gen. John J. Pershing is head, that is to supervise the plebiscite in the territory now in dispute between Peru and Chile. General Morrow served in the Panama Canal Zone from 1916 to 1924 first as assistant to the governor and later as governor. During the war, however, he was chief engineer of the First Army A. E. F. Earlier service, after being commissioned in the Corps of Engineers in 1887, was on the Lake Lanao expedition to the Philippine Islands, engineer-commissioner of the District of Columbia from 1907 to 1910, and chairman of the Alaska R.R. Commission.

EZRA B. WHITMAN, Gustav J. Requardt, Benjamin L. Smith, A. E. Falkenberg and T. W. Hacker will form the personnel of the Baltimore office of Whitman, Requardt & Smith, engineers, whose former firm name was Norton, Bird and Whitman. The offices will be at 18 Lexington St., Baltimore. William J. Norton will maintain the office of Norton, Bird and Whitman at 588 Broad St., Newark, N. J. The firm's engineering services are in surveys, reports, design and supervision of construction; sanitary, hydraulic and structural engineering; financing, valuations and rate schedules; arbitration.

DAVID A. MCCLOSKEY, engineer for Blair County, Pennsylvania, for five years, who resigned recently to move to Florida, has been elected borough manager for Hollidaysburg, Pa.

CHESTER A. ECKERT, civil engineer, New Cumberland, Pa., has been elected borough manager for Milton, Pa.

ALBERT K. WARREN, senior engineer and deputy county surveyor of Los Angeles County, California, who has been in charge of design and construction of drainage work in the Los Angeles County surveyor's office since 1914 and in charge of sanitation since 1918, has been appointed chief engineer of the Los Angeles County sanitary districts. He will be in complete charge of construction work on the county metropolitan sewerage system, for which bonds totaling more than $9,000,000 have been voted by the various sanitation districts in the county. Prior to 1914 Mr. Warren had been for many years an engineer in charge of railroad construction in the Pacific northwest where a great amount of difficult tunneling was required.

HARRY L. KENVIN, formerly of the Thompson-Starrett Co., New York City, has been elected treasurer of Wharton, Green & Co., New York City, with charge of its contract department.

LLOYD ALDRICH, consulting engineer, Los Angeles, Calif., has been appointed secretary of the Los Angeles section, American Society of Civil Engineers, succeeding Floyd G. Dessery, resigned.

L. A. STANLEY, manager of the MacDonald Engineering Co., constructing engineers, 90 West St., New York City, announces the moving of the Wichita, Kan., office of the company to 526 Board of Trade Bldg., Kansas City, Mo.

From the Manufacturer's Point of View

A Point of Contact Between Maker and User of Construction Equipment and Materials

New President for Holt Company

Charles L. Neumiller was elected president of the Holt Manufacturing Co. at a meeting of the board of directors last month; he succeeds Thomas F. Baxter who has held the presidency of the organization for the last five years. A group consisting of Pierce, Fair & Co. and associates has taken over the control of the Holt Manufacturing Co. which for 33 years has rested in the Holt family and more recently in the Benjamin Holt Corporation. In this group are included practically all members of the Holt family, M. M. Baker of Peoria, Ill., and the Benjamin Holt Corporation. The new president announced that no changes were contemplated in the affairs of the company other than those that were in due course to be dictated by good business judgment.

Important Declaration Made by Court in Johnson Suit

In declaring that the balanced valve manufactured by the Wellman-Seaver-Morgan Co., of Cleveland, Ohio, infringes the patent of the Johnson valve, which is held by the William Cramp & Sons Ship & Engine Building Co., of Philadelphia, the U. S. Circuit Court of Appeals for the Sixth Circuit, in a decision made public some time ago (see Feb. 12, 1925 issue, p. 296) made a ruling of unusual importance to the holders of structural patents.

The court in its decision said: "The valve, when put upon the market as the commercial form of the invention, differed considerably from the form shown in the drawing. As usual in such cases, counsel for the appellee (William Cramp & Sons) rely upon the large commercial adoption to show merit in the device, and opposing counsel says that the patented structure has never been manufactured at all. As is also usual in such cases, to make this reply is not helpful. If the patent is of the specific scope which defendant contends, there has been no infringement; while if it is so generic that it covered the commercial form, and this form represented the substantial invention, although with some improvements, the patentee is entitled to some or all of the credit coming from public acceptance. . . .

"In the appellant's (Wellman-Seaver-Morgan Co.) installation, which is the basis of this charge of infringement, it has carried along into some further development Johnson's commercial form, and the superficial dissimilarity to the patent is increased, but it still has appropriated the essence of the invention. It carries into the interior of the valve, to bring about extension of the telescopic section, the high hydraulic pressures from the upstream region, and this pressure co-operates with the weakened external resistance, caused by the contracted portion of the conduit, to permit the expansion and seating of the valve. It then, in order to permit and cause the contraction of the telescopic section and the unseating and opening of the valve, shuts off the interior from the high-pressure connection and opens it to a lower pressure, whereby the existing high pressure in the conduit gives the valve an initial lift from its seat and the reaction of the water flowing through the slightly opened valve co-operates in completing the opening. This complete idea it took from Johnson and from nowhere else."

Manufacturers Apply for Space at Water-Works Convention

The following manufacturers have applied for exhibit space at the convention of the American Water-Works Association, to be held in Louisville, Ky., April 27-May 2. It is probable that a number of other applications will be received before the convention.

Mueller Co., Inc.
Water Works Equipment Co.
The American City.
R. D. Wood & Co.
Public Works.
The Leadite Co.
W. & L. E. Gurley.
Thomson Meter Co.
U. S. Cast Iron Pipe and Foundry Co.
Union Water Meter Co.
Hersey Mfg. Co.
The A. P. Smith Mfg. Co.
Buffalo Meter Co.
Builders Iron Foundry.
Paragon Eng. Co.
Chicago Valve & Hydrant Co.
Bingham and Taylor.
H. W. Clark Co.
Rensselaer Valve Co.
Engineering and Contracting.
Lock Joint Pipe Co.
Fire and Water Engineering, Inc.
Wallace & Tiernan Co., Inc.
Eddy Valve Co.
Lead Lined Iron Pipe Co.
National Tube Co.
The Ludlow Valve Mfg. Co.
Neptune Meter Co.
The Kennedy Valve Mfg. Co.
Simplex Valve & Meter Co.
A. D. Cook, Inc.
Edson Manufacturing Corp.
Worthington Pump & Machinery Corp.
Birch Manufacturing Co.
McWane Cast Iron Pipe Co.
Columbian Iron Works.
Engineering News-Record.

Railway Appliances Exhibit

In the account of the exhibit of railway appliances in the Coliseum at Chicago, March 9-12, on p. 500 of the March 19 issue of this journal, it was stated that the highway crossing paving exhibited by the Alan Wood Iron & Steel Co. of Philadelphia was made up of cast-iron plates. This statement was in error. The plates for grade crossing paving are of rolled steel.

Baltimore Grain Decision Not to Retard G. E. Investigation

Washington Correspondence

Publication of a statement that the Federal Trade Commission may not attempt to investigate the General Electric Co. as a result of the Supreme Court's decision in the Baltimore grain cases, which held the Commission to be without authority to seize or search the books of a private corporation in the conduct of a general investigation, brought from the commission, on March 25, a pronouncement to the effect that no action had been taken to halt the investigation which already is underway. No comment was forthcoming, however, as to the possible effect of the Supreme Court's ruling on the conduct of the probe into the affairs of the General Electric Co.

It is understood that there will be no occasion for the commission to suspend its investigation because of doubt as to its authority to pursue it. The General Electric Co., it is said, will raise no questions as to its rights and will furnish the commission voluntarily any information necessary to a full and fair investigation as prescribed by the terms of the resolution.

Business Notes

NEW YORK CONTINENTAL JEWELL FILTRATION CO., Nutley, N. J., which has been in a receivership for some time past, last week passed into the control of the American Water Softener Co., Philadelphia, which is reported to have paid about $11,000 for the property. The filter company was a consolidation, years ago, of practically all the mechanical filter companies of the United States and for many years was the chief manufacturing concern in this field.

COL. WALTER J. RILEY, president of the O. F. Jordan Co., manufacturer of the Jordan Spreader, East Chicago, Ind., is in Europe, studying the continental railway systems. Before his return, Col. Riley will visit Turkey, the Balkan States, Poland, Hungary, Austria, Germany and France. Last year he studied the transportation facilities of China, Japan, Java and India, and in 1923 he went over the South American system.

BAKER MANUFACTURING CO., Springfield, Ill., manufacturer of road graders and scrapers, has recently appointed the following distributors: Chadwick Brothers Co., Milwaukee; Lewis Motor Co., Fargo, N. D.; Banks-Miller Supply Co., Huntington, W. Va.; Baker Equipment Co., Detroit; Beaumont Export & Import Co., Beaumont, Texas; Holt Texas Equipment Co., Dallas, Texas; Clinton & Held Company, Denver.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has received from the West Penn Power Co., a contract amounting to more than $800,000 for power equipment to be installed at Springdale, Pa. The contract calls for one 40,000-kw. turbine generator and a 62,500-sq.ft. condenser. The condenser will be the largest one of its kind installed in that section of the country.

ELLIS J. TROY, formerly with the Bethlehem Steel Corporation has recently joined the sales force of the McKiernan-Terry Drill Co. His headquarters will be in New York.

R. M. HANNAFORD, formerly acting chief engineer of Montreal Tramways Co., has been appointed engineer of maintenance-of-way and structures.

Equipment and Materials

Mortar Mixing Boxes of Steel

For use by building, road and sidewalk contractors, city street departments, and public utility corporations, the Heltzel Steel Form & Iron Co., Warren, Ohio, has placed on the market a riveted, all-steel mortar mixing box built in three sizes. The depth of the boxes is uniformly 10 in., while the

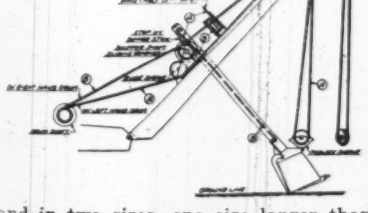
lengths and widths are 5x2 ft. 4 in.; 7 ft. 6 in. x 3 ft. 6 in.; and 11 ft. 6 in. x 4 ft. The weights are respectively, 80, 140 and 350 lb., the two smaller sizes being of 14-gage metal and the larger one of 12-gage.

Top edges are reinforced with double steel flanges, insuring rigid construction and providing grips for handling. A feature of the design is the elimination of rivets on the inside of the box, against which mixing tools might scratch; the inside surface is smooth and seamless. The all-steel construction of these boxes, in addition to insuring long life, adapts them to winter construction work when a fire may be built under the bottom to heat the materials during mixing.

For use with these boxes the company manufactures an accessory in the form of a steel saddle, to which is bolted a hod support, which slides along the side of the box.

New Cable Crowd Design in Northwest Shovel

The Northwest Engineering Co., Chicago, Ill., announces some changes in the cable crowd design of the Northwest power shovel. In the old design the boom head drum was compound

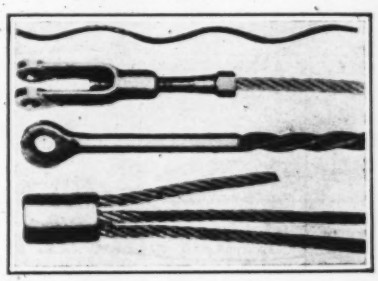


and in two sizes, one size larger than the other. The hoisting line passed over the boom head drums and was dead-ended in the larger size. The second line dead-ended in the smaller size, ran over a drum on the shipper shaft and dead-ended at the upper end of the dipper stick. Thus the hoisting line in action rotated the drum and wound up the second cable at the boom head, drawing forward the dipper stick for the thrust.

In the new design the second cable and the weight of the drum have been eliminated, thereby reducing the weight of the boom head and much of the strain on the machine. Two large diameter sheaves have replaced the drum. The hoisting cable *A* runs over one of these to the padlock sheave, back up over the other boom head sheave, down to the drum at the shipper shaft, takes a couple of turns about this and is dead-ended at the upper end of the dipper stick. Cable *B*, the holding line, runs to the shipper shaft drum and is dead-ended at the bucket.

Pre-Formed Strands Are Feature of New Wire Rope

What is claimed to be the first basic change in wire rope construction in more than a century is embodied in a new wire rope manufactured by the American Cable Co. New York, under the trade name of Tru-lay. The new principle developed in the making of the rope is the "pre-forming" of wires and strands to the exact shape they must have to fit correctly in the completed



TRU-LAY WIRE ROPE AND ITS USES
Beginning at the top: (1) a strand of Tru-lay wire; (2) Tru-lay rope with a threaded hexagon Tru-loc fitting for shackles, turnbuckles, etc.; (3) flat head-eye end fitted into rope; and (4) example of a multiple-rope Tru-loc fitting.

product. The rope is being made in Lang and regular lays up to 1 in. in diameter.

An important characteristic of the Tru-lay rope is that it resists unstranding. It can be cut at any point for splicing and otherwise handled without the necessity of seizing. Tests show, the manufacturer reports, that it has considerably longer life than ordinary rope under reversed bending stresses—an asset where winding over sheaves and drums is a chief cause of wear. The pre-forming of the wires and strands in the rope results in evenly balancing the load on individual strands and in a uniform load distribution to single wires. The rope shows no tendency to high strand in actual use and has stood up satisfactorily in winding tests under heavy loads.

To make available practically the entire strength of the new rope the American Cable Co. has developed for it a special steel fitting, without zinc, called Tru-loc. The Tru-loc fitting permits the use of turnbuckles, shackles and other equipment used with rods and chains. A steel sleeve is slipped over the smooth unseized end of the rope, placed in a specially-designed press, and made to "flow" down upon the rope until it grips wires and strands. These sleeves may be of any reasonable length and can be threaded, equipped with heads of various types for wrenches, or furnished with eyes or hooks.

The new rope is designed for use in every industry where dependable wire rope is a factor. It is now being introduced in oil-drilling operations, in the general building and construction field, in the cement and quarrying fields and in a large variety of factory and shop operations, including elevator and crane operation.

Publications from the Construction Industry

Concrete Road Building—LAKEWOOD ENGINEERING CO., Cleveland, Ohio, has issued a 10-p. booklet on the Lakewood subgrader, for which the outstanding advantages are claimed that it does the work of subgrading with a minimum of labor, that it produces a true subgrade, and that it insures against waste of concrete due to a low subgrade.

Screens — UNIVERSAL VIBRATING SCREEN CO., Racine, Wis., has just issued a 24-p. catalog describing the Universal mechanical vibrating screen, the product of the combined efforts of several of the leading engineers in the crushed stone and gravel-producing industry, with twenty-five years of practical experience behind them.

Curing Concrete Pavements — DOW CHEMICAL CO., Midland, Mich., has issued two manuals, "How to Cure Concrete" and "How to Maintain Roads." These manuals are intended to be informative rather than advertising documents and contain much of value to the concrete user and road contractor.

Hoisting Equipment—SULLIVAN MACHINERY CO., Chicago, describes the Sullivan electric portable hoists in an 8-p. bulletin. The single-drum hoist is adapted to a great variety of uses in quarries, on construction jobs, in yards, shops and foundries—wherever light haulage is needed. The double-drum hoist is used effectively for quarry and construction jobs, for moving cars of material, for trimming stock piles.

Heating—AMERICAN BLOWER CO., Detroit, Mich., has published a bulletin on the new Venturafin unit heater for use in factories and shops of all kinds. The new heater has about three times the heating capacity of the company's original heater, put on the market about a year ago. The larger unit has a capacity of 500,000 to 650,000 B.t.u. per hour.

Convertible Crane—BYERS MACHINE CO., Ravenna, Ohio, in a 48-p. booklet illustrates the uses to which its "Bear Cat" crane can be put. These include digging ditches for sewer and water main pipes, road building and grading, and general excavation work. Seventeen pages are devoted to illustrations of the equipment at work.

Engineering News-Record Statistics of the Construction Industry

April 2, 1925 — *in the United States* — Vol. 94, No. 14

Engineering News-Record CONSTRUCTION COST Index Number (1913 = 100)

MONTHLY

Jan. 1924 to Date

April, 1925	**209.55**
March, 1925	210.20
April, 1924	221.60
Peak, June, 1920	273.80
1913	100.00

1924

Jan.	217.90	May	222.33	Sept.	211.25
Feb.	220.30	June	216.85	Oct.	207.55
March	224.60	July	214.40	Nov.	205.70
April	221.60	August	213.15	Dec.	208.58

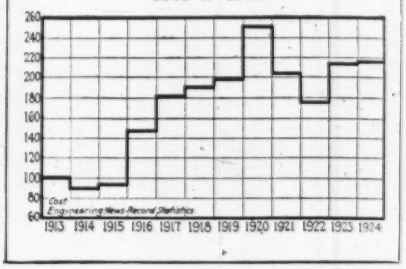
1925

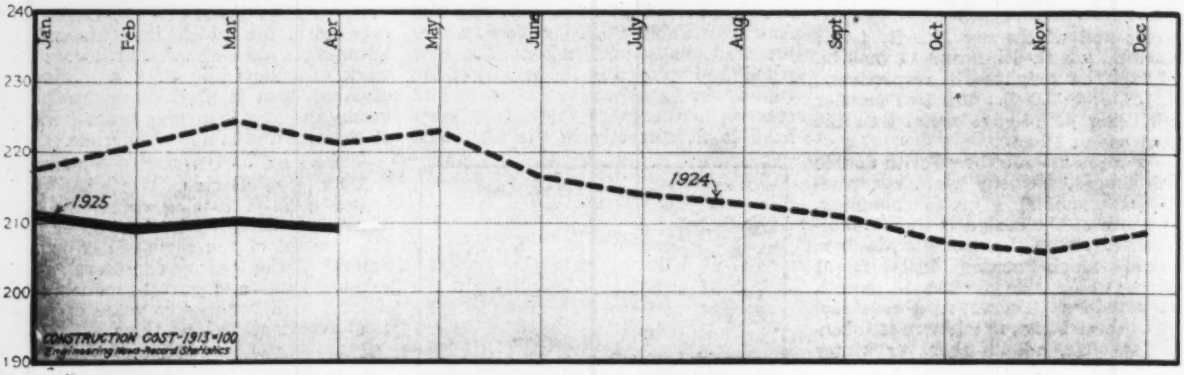
Jan.	210.40	Feb.	209.70	March	210.20

ENGINEERING NEWS-RECORD'S Construction Cost Index Number declined 0.65 points since last month owing to slightly lower cost of structural materials. The average rate for common laborers is now 54¼c. per hr. for the entire country, against 54c. two months ago and 55c. in April, 1924. Thus general construction cost is 5 per cent lower than one year ago and 23 per cent under the peak; it is 109 per cent above the 1913 level.

YEARLY

1913 to 1924





Engineering News-Record CONSTRUCTION VOLUME Index Number (1913 = 100)

MONTHLY

Jan. 1924 to March, 1925

March, 1925	**161**
February, 1925	145
March, 1924	161
Peak, May, 1922	221
1913	100

1924

January	125	May	194	September	159
February	144	June	149	October	164
March	161	July	161	November	128
April	159	August	162	December	145

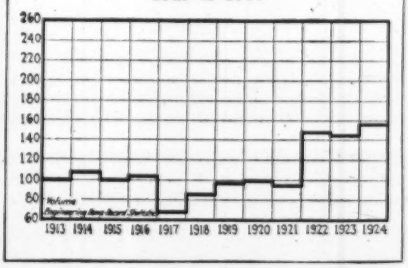
1925

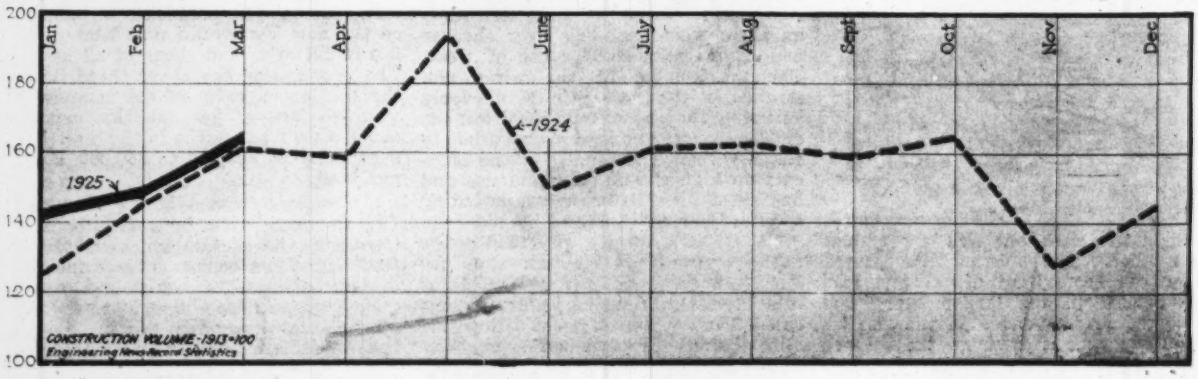
January	141	February	145

ENGINEERING NEWS-RECORD'S Construction Volume Index Number is 161 for the month of March, and 154 for the whole of 1924, as against 100 for 1913. This means that the actual volume of construction in 1924 (not the mere money-value of the contracts let that year) is 54 per cent above the volume of construction for 1913. The monthly volume number, 161 for March, 1925, contains the increment of construction and indicates the rate at which contracts are being let as is 109 per cent above the 1913 level.

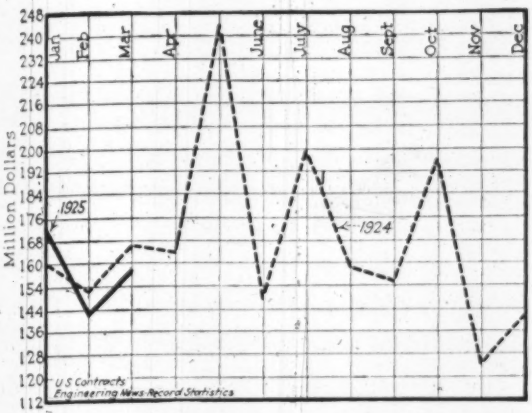
YEARLY

1913 to 1924

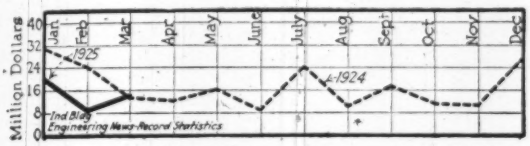




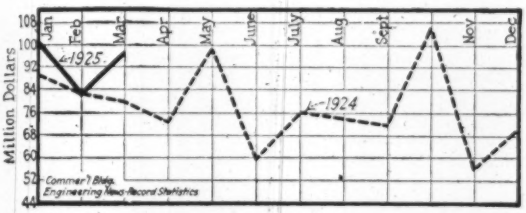
Engineering News-Record Monthly Construction Statistics



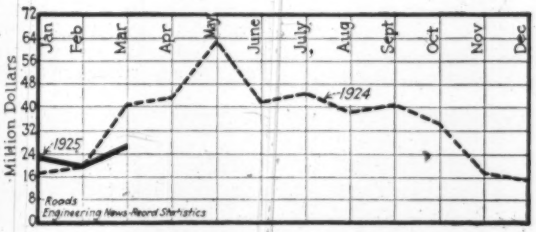
Contracts Awarded in the United States
Reported in E. N.-R.



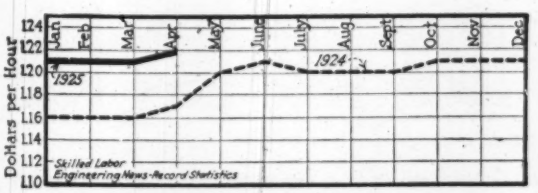
Industrial Building Awards
$40,000 and Over



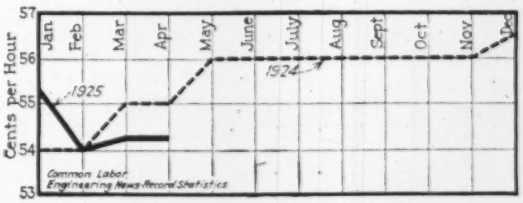
Commercial Building Awards
$150,000 and Over



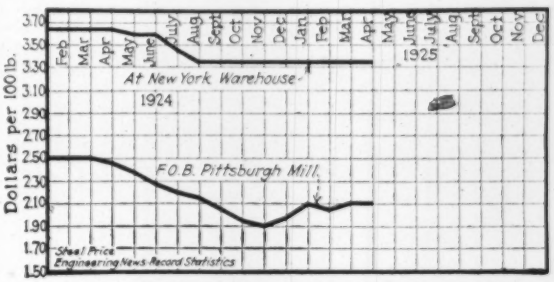
Street and Road Lettings
$25,000 and Over



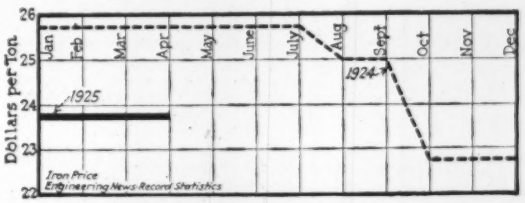
Average Wage of Skilled Building Trades
Bricklayers, Carpenters and Steel Erectors



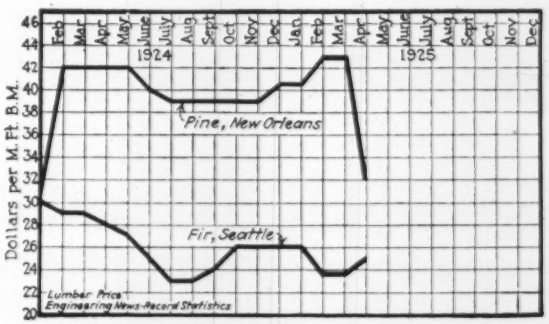
Average Common Labor Rate
Pick and Shovel Men



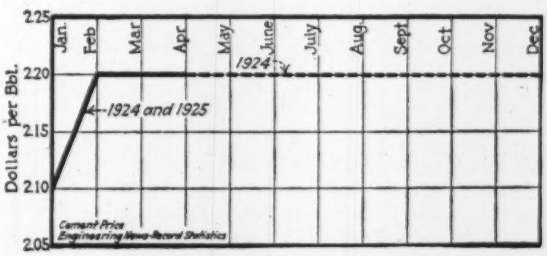
Price of Steel Structurals
Shapes 3-In.; Plates ¼-In.



Price of Basic Pig Iron
F.o.b. Pittsburgh

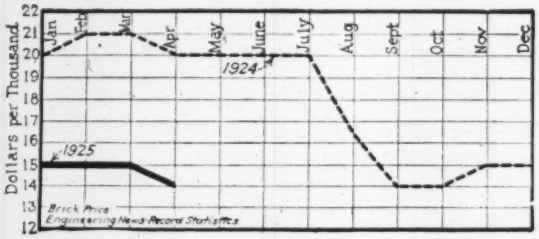


Price of Timbers, Wholesale, Base Sizes
Car Lots to Contractors

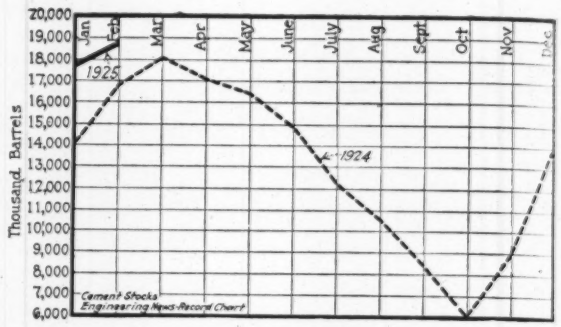

Dollars per Bbl.
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1924
1924 and 1925
Cement Price
Engineering News-Record Statistics

Net Price of Portland Cement
Car Lots, F.o.b. Chicago

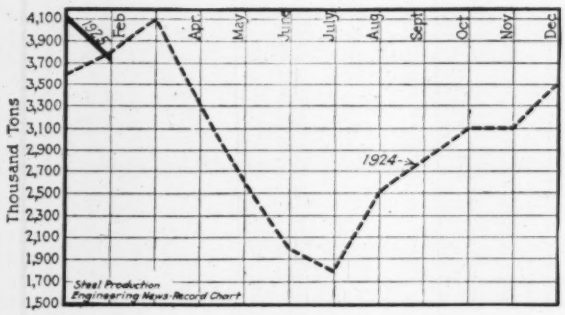
Engineering News-Record Monthly Construction Statistics



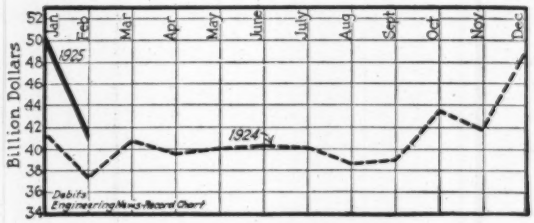
Price of Brick
At Dock, New York



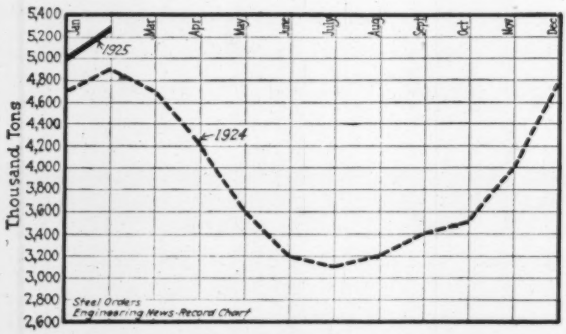
Cement Mill Stocks
Geological Survey



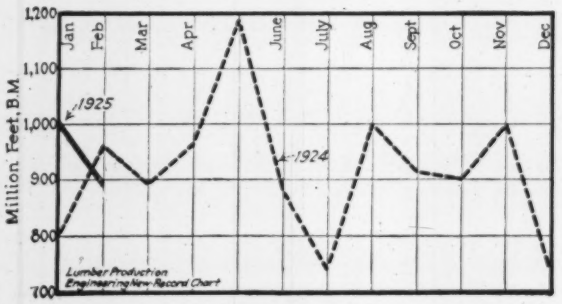
Steel Ingot Output
Gross Tons; Am. Iron and Steel Inst.



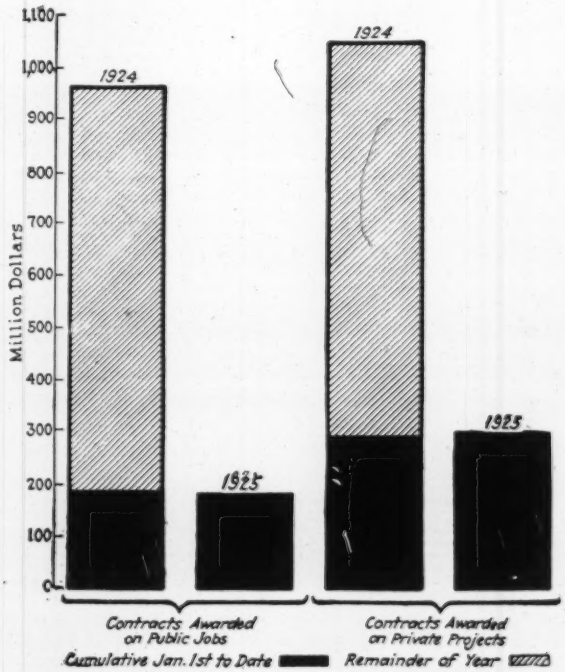
General Business Trend
Bank Debits—Federal Reserve



Unfilled Tonnage
On Books of U. S. Steel Corp.



Lumber Output
Nat. Lumber Mfrs. Assn.



Contracts Awarded—Private and Public
Reported by E. N.-R.

Actual Volume of Construction Fully as Heavy as Year Ago, Owing to Lower Cost

THE volume of March construction was identical with that of the corresponding period in the peak year 1924. This refers to the actual quantities of materials used, since in money value, the March, 1925 total was 5 per cent under that of the same month last year.

The situation was one in which, owing to a substantial reduction in cost, it was possible to buy the same amount of construction for much less money.

At the same time it will be noted that March gained over February by 11 per cent in money value of contracts let.

Taking the lettings for the first quarter of this year, a decrease of 1 per cent is shown in comparison with the corresponding period in 1924.

Contracts included in the accompanying table do not cover any lettings under $15,000 for water-works or excavations; $25,000 for other public works; $40,000 for industrial and $150,000 for commercial buildings. About 30 per cent of the total for March was for construction other than building, therefore requiring no permits.

Construction of sewers and industrial and commercial buildings is not only heavier than a month ago but also shows a substantial gain over this period in 1924.

Compared with a month ago and one year ago, current lettings show a slight slump in bridges, excavations, dredging, drainage and irrigation projects and Federal Government work.

Water-works construction, though considerably under last month, is heavier than at this time last year; an exactly opposite condition prevails in paving projects.

Construction activity is greater than a month ago, or one year ago, in New England and the states immediately west of the Mississippi. Substantial gains over last month are noted in the Middle West. Canadian construction in March doubled that of February, 1925. Construction in the Far West is slightly greater in volume than it was at this time last year.

Among the large contracts let during the month were: A theatre, store and office building at Philadelphia, Pa., $6,000,000; Harvard business school, Brighton, Mass., $5,000,000; garbage disposal system, Kansas City, Mo., $2,943,930; hospital, Kings Park, N. J., $2,527,000; terminal and office building, Los Angeles, Calif., $2,500,000; store and office building, New York, N. Y., $2,500,000; high school, Jamaica, N. Y., $2,083,980; commercial building and studio, Cleveland, Ohio, $2,000,000; power station, Sioux City, Iowa, $2,000,000; industrial plant, Kansas City, Mo., $2,000,000.

Value of Contracts Let in the United States and Canada, March, 1925

	New England	Middle Atlantic	Southern	Middle West	West of Mississippi	Far West	United States	Canada	Grand Total
Water works	$306,000	$371,000	$189,000	$1,185,000	$1,413,000	$959,000	$4,423,000	$389,000	$4,812,000
Sewers	.....	1,457,000	.....	1,768,000	3,279,000	265,000	6,769,000	248,000	7,017,000
Bridges	.....	.....	1,381,000	309,000	932,000	122,000	2,744,000	.....	2,744,000
Excavation, Dredging, etc.	.....	.....	236,000	112,000	357,000	321,000	1,026,000	.....	1,026,000
Streets and Roads	147,000	4,086,000	4,179,000	7,090,000	8,055,000	2,287,000	25,844,000	66,000	25,910,000
Industrial Building	2,155,000	3,370,000	880,003	2,160,000	3,589,000	1,299,000	13,453,000	334,000	13,787,000
Commercial Building	16,372,000	35,484,000	4,729,000	12,397,000	14,293,000	12,997,000	96,272,000	1,150,000	97,422,000
Federal Government	32,000	653,000	428,000	62,000	141,000	78,000	1,394,000	.....	1,394,000
Unclassified	148,000	438,000	1,359,000	595,000	2,096,000	350,000	4,986,000	372,000	5,358,000
March, 1925	$19,160,000	$45,859,000	$13,381,000	$25,678,000	$34,155,000	$18,678,000	$156,911,000	$2,559,000	$159,470,000
March, 1924	9,503,000	52,608,000	18,973,000	38,103,000	28,817,000	18,231,000	166,235,000	4,078,000	170,313,000
February, 1925	11,724,000	51,432,000	15,693,000	18,247,000	20,986,000	23,538,000	141,620,000	1,658,000	143,278,000
First Quarter, 1925	43,807,000	149,655,000	44,849,000	71,271,000	92,714,000	68,215,000	470,511,000	9,078,000	479,589,000
First Quarter, 1924	36,056,000	162,293,000	56,580,000	83,244,000	71,380,000	66,597,000	476,150,000	23,931,000	500,081,000

Labor Rates and Conditions Throughout the Country

REGARDLESS of the irregularities existing in the general business situation and of the slowness with which the trade revival is materializing, fundamental conditions are believed to be sounder than at any time during the past two years. Three things point in this direction, namely: the strong financial position of this country particularly with relation to credit; continued improvement in economic conditions abroad; and sustained buying power, especially in the agricultural districts.

Over-expansion of the industries, or an enlargement of plant capacities beyond the actual needs of the consuming public and at the expense of invested capital, is one of the principal dangers of the present situation.

This condition is apparently being avoided by gradual curtailment of excessive output.

Reserve materials stocks are unusually heavy; hence the lack of a tendency toward abrupt price advances in any of the basic materials.

In the construction industry there have been remarkably few wage disputes and strikes since the beginning of the current year.

Wage advances granted, have not exceeded 25c. per hr. and have, in some cases, been as small as 5c.

The trades gaining increases in various cities of the country since Jan. 1 are: carpenters, plasterers, hodcarriers, painters, plumbers, stone masons, marble setters, pipe coverers, steamfitters and asbestos workers.

From this line-up the bricklayers are conspicuously absent. Local conditions follow:

Baltimore—Normal conditions prevail in the building trades.

Birmingham—Big surplus of common laborers. No scarcity in other classes.

Boston—Carpenters and bricklayers are signed up for a continuation of the present rates for three years. Plumbers, steamfitters and electricians are reported as going on strike for the $1.25 rate as against $1.10 per hr. received at present.

Chicago—Effective June 1, marble setters and ornamental iron workers will receive an increase of 12½c. per hr., making their rate $1.25 per hr. Structural iron workers, now receiving $1.25 are asking an advance to $1.50 per hr. Carpenters and hoisting engineers are reported to be moving in the direction of an advance of 12½c. per hr. and common laborers, 5c. per hr., to take effect June 1, 1925.

Cleveland—Structural iron workers are signed up for a continuation of the present schedule until Mar. 1, 1926. Plasterers have also been granted an advance; their rate will be $1.56¼ per hr. for a 44-hr. week until Mar. 1, 1926. From Mar. 1, 1926 to Mar. 1, 1927 the rate will be $1.62½ per hr.

Dallas—Small surplus of common laborers. Most other crafts employed.

Denver—Recent demands of painters, carpenters and sheet metal workers for advance of 12½c. per hr., not yet granted. Electricians moved for rise of 25c. per hr.

Detroit—Employment in the Detroit industrial district, though lighter than a year ago, is gaining rapidly. Increasing volume of construction, particularly in building work, taking some of the surplus labor.

Kansas City, Mo.—All building crafts plentiful.

Montreal — Unemployment situation slightly improved.

New Orleans—The termination of the racing season has rid the city of the migratory element, including a certain number of common laborers.

New York—The strike threat, recently launched by ornamental iron workers, derrick men, riggers and machinery movers, was halted by a temporary injunction granted by the U. S. District Court in favor of the employing construction companies.

A strike movement is now under way between bricklayers and plasterers unions, on various jobs of the Thompson-Starrett Co. in New York, Chicago and Philadelphia. This action threatens

Current Building Trades Wage Rates Per Hour

(Higher rates indicated by +, decreases by —)

Cities	Bricklayers	Carpenters	Hoisting Engineers	Hod Carriers	Pile Drivers	Structural Iron Workers	Common Labor
Atlanta	$1.12½	$0.70	$0.70	$0.50	.....	$0.75	$0.25@.30
Baltimore	—1.50@1.75	+1.00@1.20	1.00@1.12½	1.00	$0.65	1.12½	.40
Birmingham	1.00@1.50	+ .35@.87½	.75@1.25	.50@.75	.....	.75@1.25	.25@.40
Boston	1.25	1.10	1.25@1.35	.82½	1.05	1.10	.50@.75
Cincinnati	1.50	1.25	1.25	.92½	1.25	1.25	.55
Chicago	1.50	1.15@1.25	1.10@1.25	1.00	1.25	1.25	.75@.82½
Cleveland	1.50	1.25	1.30	.87½	1.00	1.50	.87½
Dallas	1.50	1.00	1.00	.40@.75	.87½	1.00	.30@.50
Denver	1.62½	1.12½	1.12½@1.18¾	.81¼@.87½	1.00	1.15⅝	.35@.55
Detroit	1.50	.90@1.00	.85@1.00	.90	.85@1.00	1.12½	.60@.75
Kansas City	—1.37½	—1.12½	1.12½@1.25	.90	+1.25	+1.25	— .35@.75
Los Angeles	1.00@1.25	.87½@.100	.75	.87½@1.12	.87½	.87½@1.00	.50
Minneapolis	1.12½	.87½	.87½	.71½	.....	.87½	.50@.55
Montreal	.90	.45@.65	.62½	.30@.35	.50	.65	.25@.30
New Orleans	1.25	.90	1.00	.65	.80	+1.25	.35@.40
New York	1.50	1.31¼	1.50	1.00	1.00@1.12½	1.50	—.50@.75
Philadelphia	1.50	1.12½	1.02½	1.12½	1.00	1.12½	.40@.45
Pittsburgh	1.55	1.37½	1.25@1.37½	1.00	.....	1.37½	.70
St. Louis	1.75	1.50	1.50@1.65	1.15@1.25	1.50	1.50	.45@.77½
San Francisco	1.25	1.00	1.00	.81¼	1.00	1.12½	.50@.55
Seattle	1.37½	1.00	1.00@1.12½	1.00	1.00@1.12½	1.12½	.50@.62½

to embarrass activities of electricians and painters on these projects.

The dispute arose over an alleged violation of a fourteen year old agreement between bricklayers and plasterers, in which the former accuse the latter of encroachment upon jurisdictional rights.

Philadelphia—No shortage of building labor in any craft.

St. Louis—Hoisting engineers are demanding increases of 12½c. to 30c. per hr., making the scale $1.80. A strike is threatened. The Building Laborers District Council has voted for a flat increase of 12½c. per hr., effective June 11. This move meets with the approval of the Building Trades Council.

San Francisco — Construction continues active. Other lines of business slowing down.

Monthly Prices of Construction Materials

Ups and Downs of the Market

THE slight drop in construction cost, from the March level, is due mainly to lower prices of structural materials. Weakness is apparent in c.-i. and sewer pipe, lime, brick, lumber, steel sheets and linseed oil. Concrete aggregates are also cheaper in certain localities. Firmness prevails in such items as, asphalt, stone paving materials, tile, rivets, nails and rope.

Pig Iron—There has been no definite price movement during the past month. Volume of current sales is limited and since the reduction in wages at the Connellsville coke ovens, the probability of immediate rise in price is small. Foreign iron is offering little competition at the present time.

Railway Supplies—Buying is particularly active in this class of materials. Most of the orders are for rails and car material. Prices are unchanged at mills.

Pipe—Jobbers stocks are limited. Steel pipe is holding its own as to price. Present weakness in c.i. pipe is due almost entirely to keen competition from foreign makers. In sewer pipe, there were two declines and one advance in price schedules out of twenty cities reporting.

Road and Paving Materials—Contract letting for road work has increased at least 30 per cent during the past thirty days. The decided firmness prevailing in asphalt and stone paving materials is not evident in road oils.

Sand, Gravel and Crushed Stone—The few declines occurring in prices of concrete aggregates during the past month, were all in the territory lying east of the Mississippi. West of the Mississippi the tendency is toward firmness.

Lime and Cement—The trend in lime is downward; cement, however, remains stationary. Cement shipments are active; stocks are unusually large, despite a drop in production.

Brick and Hollow Tile—Price of tile is rising while the brick market has not yet recovered from the mid-winter slowness. Tile is higher in St. Louis, Kansas City and the factories supplying New York, while brick is slightly easier in New York and Boston markets.

Structural Steel—Demand is active, particularly for use in large commercial buildings. The recent maximum of $2.20 per 100 lb., f.o.b. Pittsburgh, did not hold. Quotations above $2.10 are seldom heard in the current market.

Lumber—The increase in cutting is commensurate with the enlargement of demand as the season advances. The price situation is uneven and reserve stocks are large. Yellow pine car framing, sills and decking, upper grades of flooring, finish and special cutting lumber are all in good demand. Pine is higher in New York, Atlanta and Detroit and on the down-trend in Boston, Minneapolis, Cincinnati, Philadelphia, St. Louis and New Orleans, compared with a month ago. Fir is firmer in Philadelphia and Seattle and cheaper in San Francisco, Boston, Cincinnati and Denver. Hemlock and spruce timbers are up in the Philadelphia market and lower in Cincinnati and Denver.

Iron and Steel Scrap—Slight firmness in the Pittsburgh district is attracting attention, although the market is off about $1 per ton in several other centers.

Miscellaneous Materials—Firmness is noted in such items as, rivets (structural and boiler) nails and rope. Steel sheets and linseed oil are weaker.

Business Briefs

Call money rates ranged from 4½ to 5 per cent, March 30.

Time loans: short terms, 4@4¼ per cent; longer periods, 4¼@4½ per cent.

Commercial paper: best names, 4 per cent; other names, 4½ per cent.

Foreign exchange: The situation in London, Paris, Rome and Berlin, follows:

	Normal	This Week	Last Week	Year Ago
Sterling	$4.8665	$4.77⅛	$4.77⅛	$4.29⅜
Franc	.193	.0535½	.0520½	.0551
Lira	.193	.0412½	.0406½	.0437½
Mark	.238	.238	.238	.....

E. N.-R. Prices of Construction Materials

Price advances since last month are indicated by **heavy type**; declines by *italics*

PIG IRON—Per Gross Ton f.o.b.:

	Apr. 2	One Year Ago
CINCINNATI		
No. 2 Southern (silicon 2.25@2.75)	$26.05	$25.05
Northern Basic	23.77	24.00
Southern Ohio No. 2 (silicon 1.75@2.25)	23.77	24.00
NEW YORK, tidewater delivery		
Southern No. 2 (silicon 2.25@2.75)	32.25	28.00
BIRMINGHAM		
No. 2 Foundry (silicon 2.25@2.75)	22.00	22.50@23.00
PHILADELPHIA		
Eastern Pa., No. 2X (2.25@2.75 sil.)	24.76	24.25
Virginia No. 2 (silicon 2.25@2.75)	30.17	28.17
Basic	24.76	24.00
Gray Forge	23.75	24.00
CHICAGO		
No. 2 Foundry Local (silicon 1.75@2.25)	22.00	24.50
No. 2 Foundry Southern (silicon 2.25@2.75)	28.01	27.00
PITTSBURGH, including freight charge from the Valley		
No. 2 Foundry Valley (silicon 1.75@2.25)	23.77	25.77
Basic	23.77	25.77
Bessemer	23.77	26.77

SCRAP—The prices following are f.o.b., per gross ton paid to dealers and producers:

	New York	Chicago	Birmingham
No. 1 railroad wrought	$14.00	$16.50@17*	*$13@14*
Stove plate	11.00	15@15.50*	*14.50@15.50*
No. 1 machinery cast	14.00	19@19.50*	17.00@17.50
Machine shop turnings	*9.00*	12@12.50	8@9
Cast borings	10.00	15@15.25	15@16
Railroad malleable	13.00	20@20.50	*16.50@17*
Re-rolling rails	14.00	19.50@20	*16.50@17*
Re-laying rails	20.00	25@31	*20.50@21*
Heavy melting steel	*12.00*	18@18.50	

*Per net ton.

Railway Supplies

STEEL RAILS—The following quotations are per ton f.o.b. for carload or larger lots. For less than carload lots 5c. per 100 lb. is charged extra:

	Pittsburgh				
	Apr. 2	One Year Ago	Birmingham	Chicago	St. Louis
Standard bessemer rails	$43.00	$43.00	$43.00	$43.00	$46@49
Standard openhearth rails	43.00	43.00	43.00	43.00	48@52
Light rails, 8 to 10 lb.	33@36	40@43	36@38	1.90@2.00*	
Light rails, 12 to 14 lb.	33@36	40@43	36@38	1.90@2.00*	2.05@2.15*
Light rails, 25 to 45 lb.	36.00	40@43	36@38	1.90@2.00*	1.95@2.10*
Re-rolled rails	27@32	39@40			

*Per 100 lb.

RAILWAY TIES—For fair-sized orders, the following prices per tie hold:

	6 In. x 8 In. by 8½ Ft.	7 In. x 9 In. by 8½ Ft.
Chicago, White Oak	$1.60	$2.00
Chicago, (creosoted) (zinc treated)	1.70	2.10
San Francisco, Green Douglas Fir	.84	1.14
San Francisco, Empty Cell Creosoted, Douglas Fir	1.70	2.25
St. Louis, White Oak, plain	**1.30**	**1.50**
St. Louis (creosoted) (zinc treated)	**1.70**	**2.00**
St. Louis, Red Oak, plain	**1.15**	**1.35**
St. Louis, Sap pine-cypress	**1.10**	**1.35**
Birmingham, White Oak	1.25	1.45

TRACK SUPPLIES—The following prices are base per 100 lb. f.o.b. Pittsburgh mill for carload lots, together with the warehouse prices at the places named:

	Pittsburgh					
	Apr. 2	One Year Ago	Chicago	St. Louis	San Francisco	Birmingham
Standard spikes, ⅝-in. and larger	$2.90	$3.00@3.15	$3.55	**$3.65**	$4.35	$2.90
Track bolts	3.90@4.25	4.00@4.25	*4.45*	4.55	5.85	3.90
Standard section angle bars	2.75	2.75	3.30	3.40	4.00	3.85

Pipe

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 to 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

WROUGHT PIPE—From warehouses at the places named the following discounts hold for steel pipe:

	Black			
	New York	Chicago	Birmingham	St. Louis
1 to 3 in. butt welded	53%	59½%	62%	49%
3½ to 6 in. lap welded	48%	56½%	59%	46%

	Galvanized			
	New York	Chicago	Birmingham	St. Louis
1 to 3 in. butt welded	39%	48%	50½%	36%
3½ to 6 in. lap welded	35%	45%	47½%	33%

Malleable fittings, Classes B and C, banded, from New York stock sell at list plus 4%; class A, plus 23%. Cast iron, standard sizes, 36% off.

CAST-IRON PIPE—The following are prices per net ton for carload lots:

	Birmingham	Pittsburgh	New York Apr. 2	New York One Year Ago
4 in.	$52.20@54.20	$53.20@54.20	*$57.60@58.60*	$66.60@68.60
6 in. and over	48.20@50.20	49.20@50.20	*52.60@53.60*	61.60@63.60

	Chicago	St. Louis	San Francisco
4 in.	*$53.20@54.20*	*$51.60*	**$59.00**
6 in. and over	*49.20@50.20*	*47.60*	**55.00**

Gas pipe and Class "A," $4 per ton extra.

CLAY DRAIN TILE—The following prices are per 1,000 lin.ft.:

Size, In.	New York Apr. 2	New York One Year Ago	St. Louis	Birmingham	San Francisco	Dallas
3	$48.00	$45.00	$40.00	$45.00		$73.00
4	50.00	55.00	40.00	56.00	$76.50	110.00
5	70.00	80.00		80.00	97.75	118.00
6	92.00	105.00	70.00	100.00	127.50	150.00
8	160.00	170.00	170.00	165.00	212.50	210.00

SEWER PIPE—The following prices are in cents per foot for standard pipe in car load lots, f.o.b., except as otherwise stated:

Size, In.	New York Delivered	Pittsburgh	Birmingham	St. Louis	Chicago	San Francisco	Dallas
3	....	$0.09	$0.10	....	....	$0.12	
4	....	.09	.10	$0.10	....	.15	$0.15
5	....	.135	.135	....	....	.18	.18
6	$0.21	.135	.135	.14	....	.21	.21
8	.35	.21	.21	.225	....	.30	.325
10	.52	.315	.315	.315	....	.42	.476
12	.66	.405	.45	.405†	....	.56	.612
15	1.14†	.54	.54	.675†	....	.90	1.02
18	1.65†	.75	.75	.945†	....	1.32	1.53
20	1.98†	.90	.90	1.26†	....	....	....
22	2.65†	1.20	1.20	....	....	....	1.564
24	2.97†	1.35	1.35	1.62†	....	2.16	2.04
27	4.65†	2.665	2.665	2.45†	....	3.00	3.34
30	5.16†	2.952	2.925	3.00†	....	3.60	4.06
33	6.98†	3.96	3.96	3.55†	....	....	4.99
36	8.00†	4.51	4.51	3.95†	....	....	5.42

	3	5	8	12	24	36
Boston	$0.13	$0.20	*$0.325*	*$0.65*	*$2.10†*	*$5.75†*
Minneapolis	....	....	*.25*	*.45*	*1.50*	4.76
Denver	.135*	.18*	.27	.47	1.70	
Seattle	.14	....	.35	.72†	2.60†	
Los Angeles	.1625	.195	.275	.495	1.65	
New Orleans	.115*	.177*	.295	.5015	*1.917*	
Cincinnati	.105	.1575	.245	.4725	1.575	4.715
Atlanta	**.11***	.15*	.25	.425	1.625	....
Montreal	.68‡	.45†	.70	1.35	4.50†	
Detroit	**.105**	**.1575**	**.245**	**.4725**	**2.16†**	**5.6375†**
Baltimore	.111	.166	.259	.499	1.665	4.92
Kansas City, Mo.	*.15**	*.21**	*.33‡*	.52		
Philadelphia	.12	.18	.28	.54	1.80	4.61

4-in., 6-in., 9-in., respectively. †Double Strength. ‡3-in. special.

Road and Paving Materials

ROAD OILS—Following are prices per gallon in tank cars, 8,000 gal. minimum f.o.b. place named:

		Apr. 2	One Year Ago
New York, 45% asphalt	(at terminal)	*$0.065* @	$0.07 $0.053
New York, 65% asphalt	(at terminal)	*.0675@*	.0725 .051
New York, binder	(at terminal)	*.07* @	.075 .06
New York, flux	(at terminal)	*.07* @	.075 .04
New York, liquid asphalt	(at terminal)	*.07* @	.075 .048
St. Louis, 40@50% asphalt		*.0545*	.048
St. Louis, 50@60% asphalt		*.0559*	.049
Birmingham, 55% asphalt		.0475	
Dallas, 45% asphalt		.0495	.0495
Dallas, 55% asphalt		.0455	.0455
Dallas, binder		.061	.061
San Francisco, binder, per ton		12.00*	9.50*

* F.o.b. Oleum, Cal. Freight to San Francisco, 80c. per ton.

E. N.-R. Prices of Construction Materials

ASPHALT—Price per ton in packages (350-lb. bbls. or 425-lb. drums) and in bulk in carload lots, f.o.b. points listed:

	Package	Bulk
New York (*Mexican*)	$23.50*	$19.50
Boston (*Mexican*)	21.00	16.00
Chicago (*Stanolind*)	21.00	15.00
San Francisco, *f.o.b. refinery*, Oleum, Cal.	18.00	12.00
Dallas (*Texas*)	27.10	21.10
Seattle, *"D" grade, California, f.o.b. Richmond*	22.25	20.50
Denver (*California*)	24.00	
Minneapolis, *f.o.b. Twin Cities* (*Stanolind*)	27.60	21.60
St. Louis (*Mexican*)	*23.75*	*21.50*
Baltimore (*Mexican*)	18.00	14.00
Montreal (*Imperial*)	28.00	21.00
Atlanta (*Mexican*)	29.75	25.75
Detroit (*Mexican*)	22.00	18.00
Cincinnati (*Kentucky Rock*)		11.65
Maurer, N. J. (*Bermudez*)	30.00	28.00
Maurer, N. J. (*Mexican*)	24.00	22.00
Philadelphia (*Mexican*)	22.50	18.00
Kansas City (*Texas*)	27.30	22.30
Los Angeles (*"D" grade, California*)	19.50	13.50†
Birmingham (*Mexican*)	27.00	21.00
New Orleans (*Mexican*)	23.00	17.00

*In drums. †f.o.b. El Segundo Refinery.

NOTE—Barrels or drums are optional in most cities. About 6 bbls. to the ton, and from 4 to 5 drums; 200 to 300 gal. to the ton.

PAVING STONE—

New York (grade I).	5-in. granite, 30 blocks per sq.yd.	$142.00 per M.
Chicago	About 4x8x4 dressed	per sq.yd.
	About 4x8x4 common	per sq.yd.
San Francisco	Basalt block 4x7x8	70.00 per M.
Boston	5-in. granite, 28 blocks per sq.yd.	130.00 per M.
Atlanta	Granite	2.50 per sq.yd.
Detroit	5-in. Granite	3.00 per sq.yd.
Baltimore	Granite	2.85 per sq.yd.
Montreal	Granite	104.75 per M.
New Orleans	Granite, 4x8x4	3.25 per sq.yd.
Cincinnati	Granite	135.00 per M.
St. Louis	4x8x4	1.65 per sq.yd.
Kansas City	Granite	4.00 per sq.yd.
Philadelphia	Granite	3.00@4.50 per sq.yd.
Minneapolis	Sandstone	2.74 per sq.yd.

FLAGGING—

New York	Bronx, 4 ft. wide	$0.24 per sq.ft.
	Manhattan, 4 ft. wide	.24 per sq.ft.
	Queens, 5 ft. wide	.26 per sq.ft.
	6x24-in. cross-walk	1.25 per lin.ft.
Chicago	18 in. wide	..... per lin.ft.

CURBING—*New York*: Bluestone per lin.ft., f.o.b. barge New York, 5x16 in., **88c.**; 5x20 in., Queens, **$1.00**. *St. Louis*: Class "A" straight, delivered, 5x18 in., **$1.05** per lin.ft.; roundings, **$1.60**.

WOOD BLOCK PAVING—

	Size of Block	Treatment	Per Sq.Yd
New York	3	16	$2.51
New York	3½	16	2.82
Boston	3½	18	2.55
Chicago	4	16	.....
Chicago	3½	16	.....
St. Louis	3½	16	2.40
St. Louis	4	16	2.70
Seattle	4	16	Off market
Minneapolis	3½	16	*2.49*
Atlanta	3½	16	2.00
New Orleans	3	16	2.20
New Orleans	3½	16	2.30
New Orleans	4	16	2.40
Dallas	4	18	3.90
Baltimore	3½	16	None used
Montreal	4	16	4.50
Detroit	3	16	1.94
Detroit	4	16	.....
Cincinnati	3½	16	2.38
Kansas City	4	16	3.95
Philadelphia	4	16	None used

Construction Materials

SAND AND GRAVEL—Price for cargo or carload lots to contractor is as follows, per cu.yd.:

	Gravel 1½ In. Apr. 2	Gravel 1½ In. One Year Ago	Gravel ¾ In. Apr. 2	Gravel ¾ In. One Year Ago	Sand Apr. 2	Sand One Year Ago
New York (*alongside dock*)	$1.75	$2.00	$1.75	$2.00	*$1.00*	$1.25
Denver	1.90	1.90	1.90	1.90	1.00	1.00
Chicago	*2.75*	2.00	*2.75*	2.00	*2.75*	2.00
St. Louis	1.45	1.45†	1.65	1.45†	1.18	1.20
Seattle	1.50	1.50	1.50	1.50	1.50	1.50
Dallas	2.38	2.38	2.38	2.38	2.00	2.00
Minneapolis	1.65*	1.85*	1.65*	1.85*	1.25‡	1.50
Cincinnati	1.40†	1.35	1.40†	1.35	1.35†	1.20†
San Francisco	2.15	2.15	2.15	2.15	1.50	1.50
Boston	1.50†	1.35†	1.50†	1.35†	1.00†	1.05†
New Orleans	*2.60*	2.85	*2.60*	2.85	1.75	1.25
Los Angeles	*1.30†*	2.15	*1.30*	2.20	1.05†	1.70
Atlanta	1.90†	2.00†	1.90†	2.00†	1.40†	1.40†
Detroit	2.02	2.02	2.02	1.75	1.62	1.35
Baltimore	1.40	1.40	1.60	1.60	0.70†	0.70†
Montreal	1.25†	1.25†	1.25†	1.50†	1.25†	1.25†
Birmingham	2.00		2.00		1.45†	1.14†
Philadelphia	2.10	2.00	2.10	2.00	1.50	1.50
Kansas City (Jobbing chats)	4.00		4.00		0.66*†0.66*†	

New York—Grits, *$1.75* per cu. yd.; ready mixed, $2.00.
Los Angeles—Freight from quarry, 70c. per ton, and is included in above price.
* At pit. † Per ton.

CRUSHED STONE—Price for cargo or carload lots, f.o.b. city, is as follows, per cu.yd.:

	1½ In. Apr. 2	1½ In. One Year Ago	¾ In. Apr. 2	¾ In. One Year Ago
New York	$1.75	$1.75	$1.85	$1.85
Chicago	*2.75*	2.00	*2.75*	2.00
St. Louis	1.83*	1.75*	1.93*	1.75*
Dallas	2.40	2.83	2.83	2.83
San Francisco	2.15	2.15	2.15	2.15
Boston	1.60*	1.45*	1.60*	1.45*
Minneapolis	1.75	1.85	1.75	2.00
Kansas City	1.50	1.50	1.50	1.50
Denver	2.50	3.50	2.50	3.50
Seattle	3.00	3.00	3.00	3.00
Atlanta	2.00*	2.00*	2.00*	2.00*
Cincinnati	1.90*	1.75*	1.90*	1.75*
Los Angeles	1.60*	.....	1.55*	.....
Detroit	*1.50*	1.75	*1.50*	1.75
Baltimore	2.50	2.50	2.55	2.55
Montreal	1.80*	1.80*	1.80*	1.90*
Philadelphia	2.10	2.10	2.10	2.10
Pittsburgh	2.85	2.85	2.85	2.85
Cleveland	3.25*	3.25*	3.25*	3.25*
Birmingham	2.00	.....	2.00	.....

*Per ton.

CRUSHED SLAG—Price of crushed slag in carload lots, per net ton, at plants:

	1½-In.	¾-In.	Roofing	Sand
Youngstown District	$1.25	$1.35	$2.00	$1.25
Steubenville District	1.25	1.30	2.00	1.30
Ironton District	1.40	1.40	2.00	1.40
Easton, Catasauqua, Pa.	.....	.....	2.50	.....
Birmingham, Ala.	.90	1.15	2.05	.80
Buffalo, N. Y., and Erie, Pa.	1.25	1.25	2.25	1.25
Cleveland, Ohio	1.30	1.30	1.30	1.30
Eastern Pa. and Northern N. J.	1.25	1.25	2.50	1.25
Western Pennsylvania	1.25	1.25	2.50	1.25
Longdale and Glen Wilton, Va.	1.25	1.25	2.50	.....
Toledo, Ohio	1.25	1.25	1.50	1.25

LIME—Warehouse prices:

	Hydrated, per Ton Finishing	Hydrated, per Ton Common	Lump, per Barrel Finishing	Lump, per Barrel Common
New York	$18.20	$12.00@$13.10	$3.50*	$2.50@2.75*
Chicago	20.00	.....	.....	*1.35†*
St. Louis	24.00	20.00	.....	14.00‡
Boston	20.00	*14@15*	*3.75**	*3.00**
Dallas	20.00	.....	.....	1.85†
Cincinnati	16.80	14.30	.....	13.40‡
San Francisco	22.00	.....	.....	1.60†
Minneapolis	25.50	21.00 (white)	1.60@1.70†	1.35†
Denver	24.00	.....	.....	2.70†
Detroit	*15.50*	15.50	20.00‡	20.00‡
Seattle, *paper sacks*	24.00	.....	2.80†	.....
Los Angeles	18.00	.....	.....	2.70†
Baltimore	24.25	17.85	2.55†	.....
Montreal	.....	21.00	.....	10.50‡
Atlanta	22.50	14.00	2.10†	1.45†
New Orleans	24.50	17.00	2.00†	2.00†
Philadelphia	23.00	16.00	.....	.....
Kansas City	*19.50*	*18.50*	2.45*	1.93*
Birmingham	22.50	15.00	2.10†	1.75†

*Per 280-lb. bbl. (net). †Per 180-lb. bbl. (net). ‡Per ton.

NATURAL CEMENT—Price to dealers per bbl. for 500 bbl. or over, exclusive of bags:

	Apr. 2	One Year Ago
Minneapolis (Rosendale)	$2.80	$2.80
Kansas City (Ft. Scott)	*1.85*	1.80
Cincinnati (Utica)	1.72	1.72
Boston (Rosendale)	2.50	2.70
St. Louis (Carney)	2.35	1.95
Birmingham (Magnolia) pozzolan cement	2.40	2.10

PORTLAND CEMENT—Prices to contractors per bbl. in carload lots f.o.b. points listed *without bags*. Cash discount not deducted.

	Apr. 2	One Month Ago	One Year Ago
New York, del. by truck	$2.50@2.60	$2.50@2.60	$2.50@2.60
New York, alongside dock to dealers	2.15	2.15	2.15
Jersey City	2.33	2.33	2.33
Boston	2.55	2.55	2.65
Chicago	2.20	2.20	2.20
Pittsburgh	2.19	2.19	2.19
Cleveland	2.39	2.39	2.39
Detroit	2.35	2.35	2.40
Indianapolis	2.41	2.41	2.41
Milwaukee	2.35	2.35	2.35
Duluth	2.19	2.19	2.19
Peoria	2.37	2.37	2.37
Cedar Rapids	2.44	2.44	2.40
Davenport	2.39	2.39	2.39
St. Louis	2.30	2.30	2.20
San Francisco	*2.31*	2.61	2.61
New Orleans	2.40	2.40	2.40
Minneapolis	2.42	2.42	2.42
Denver	2.84	2.84	2.84
Seattle	2.65	2.65	2.90
Dallas	2.05	2.05	2.05
Atlanta	2.30	2.30	2.35
Cincinnati	2.47	2.47	2.47
Los Angeles	2.80	2.80	3.00
Baltimore	2.90	2.90	2.50
Birmingham	2.40	2.40	2.65
Kansas City, Mo.	2.28	2.07	2.30
Montreal	1.80	1.80	2.72
Philadelphia	2.41	2.41	2.41
St. Paul	2.42	2.42	2.42
Toledo	2.40	2.40	2.40

NOTE—Bags 10c. each, 40c. per bbl.; 20c. each in Canada, 80c. per bbl.

Current mill-prices per barrel in carload lots, without bags, to contractors:

Buffington, Ind.	$1.95	Hudson, N. Y.	$2.05
Universal, Pa.	1.95	Leeds, Ala.	1.95
Steelton, Minn.	2.00	Hannibal, Mo.	2.05
Fordwick, Va.	2.05	Lehigh Valley District	1.95
Mitchell, Ind.	2.05	Wyandotte, Mich.	2.10
Iola, Kan.	1.95	Alpena, Mich.	*1.95*
Mason City, Ia.	2.00	Richard City, Tenn.	2.05
La Salle, Ill.	2.05	Kingsport, Tenn.	2.05

E. N.-R. Prices of Construction Materials

TRIANGLE MESH—Price per 100 sq.ft. in carload lots:

PLAIN 4-INCH BY 4-INCH MESH

Style Number	Weight in Pounds per 100 sq.ft.	Pittsburgh Mill	Birmingham Mill	Warehouse: New York	St. Louis	Dallas	San Francisco
032	22	$0.97	$0.95	$1.39	$1.06	$1.13	$1.20
049	28	1.23	1.25	1.76	1.35	1.38	1.42
068	35	1.51	1.50	2.16	1.66	1.67	1.87
093	45	1.94	1.93	2.77	2.13	2.00	2.40
126	57	2.39	2.38	3.45	2.63	2.55	2.97
153	68	2.86	2.85	4.11	3.14	3.15	.....
180	78	3.28	3.28	5.70	3.60	3.47	.....
245	103	4.33	4.42	6.21	4.75	4.58	.....
287	119	5.00	4.95	7.19	5.50	5.26	6.23
336	138	5.80	5.75	8.35	6.37	6.11	.....
395	160	6.72	6.50	9.65	7.38	7.12	.....
PAVING							
036P	17	$0.74	$0.74	$1.06	$0.81	$0.76	.....
053P	24	1.04	1.05	1.50	1.14	1.07	.....
072P	31	1.32	1.32	1.90	1.45	1.39	.....
097P	40	1.70	1.70	2.45	1.87	1.90	.....
049R	24	1.04	1.04	.....	1.14	1.07	.....
067R	31	1.32	1.30	.....	1.45	1.39	.....
089R	40	1.70	1.70	.....	1.87	1.90	.....

In rolls, 48-, 52-, and 56-in. wide and in 150-, 200- and 300-ft. lengths. Galvanized is about 15% higher. Size of roll carried in New York warehouses, 48 in. wide x 150 ft. long, or 600 sq.ft.

EXPANDED METAL LATH—Prices in carload lots per 100 yd. for painted:

Weight in pounds	New York	Birmingham	St. Louis	San Francisco	Dallas
2.2	$19.00	$22.00	$21.00	$24.00	$23.50
2.5	20.50	23.00	23.00	26.00	25.00
3.0	23.50	26.00	27.00	30.00	28.50
3.4	25.00	28.00	29.00	.....	31.00

BARS, CONCRETE REINFORCING—Current quotations per 100 lb.:

ROLLED FROM BILLETS

Inches	Pittsburgh Mill	Birmingham	Warehouse, Uncut: New York	Chicago	St. Louis	Dallas	San Francisco
½ and larger	*$2.10@2.20*	$2.25	$3.24	$3.00	$3.15	$3.38	$3.35
⅝	*2.20@2.30*	2.35	3.34	3.10	3.25	3.43	3.45
¾	*2.30@2.40*	2.45	3.44	3.20	3.33	3.48	3.55
⅞	*2.50@2.60*	2.65	3.64	3.40	3.55	3.63	3.75
1	*3.10@3.20*	3.25	4.24	4.00	4.15	3.78	4.35

For size and cutting extras, see bar card of July 15, 1923.

ROLLED FROM RAILS

	St. Louis	Dallas		St. Louis	Dallas
½ and larger	$2.65*	$3.08	½	$3.05*	$3.30
⅝ in.	2.75*	3.13	¼	3.65*	3.48
¾	2.85*	3.18	.....	.....	.....

* Warehouse shipments.

BRICK—Contractors price per 1,000 in cargo or carload lots is as follows:

	Common: Apr. 2	One Month Ago	One Year Ago	Paving Block: 3-inch*	4-inch*
New York (del.)	*$17.00*	$18.00	$23.65	$45.00	$51.00
New York (at dock)	15.00	15.00	20.00	.....	.....
Chicago	12.00	12.00	11.00	50.00	50.00
St. Louis, salmon (del.)	16.00	16.00	16@18	.....	42.50
Denver, salmon	12.00	12.00	12.00	.....	.....
Dallas	12.10	12.10	13.60	35.00	.....
San Francisco	15.50	15.50	15.50	.....	.....
Los Angeles	13.00	13.00	14.50	(not used)	
Boston (del.)	*18.50*	19.00	21.50	45.00	51.00
Minneapolis (del.)	13.50@13.60	13.50	14.50	.....	.....
Kansas City	14.50	14.50	16.50	(no market)	
Seattle	14.50	14.50	15.00	.....	42.50
Cincinnati	17.00	17.00	17.00	40.00	45.00
Montreal	17.50	17.50	17.50	100.00†	68.00
Detroit (del.)	17.50	17.50	17.50	38.50	41.50
Baltimore	18.00	18.00	21.00	40.00	45.00
Atlanta	10.50	10.50	12.00	40.00	.....
New Orleans	15.00	15.00	18.75	.....	.....
Birmingham	12.50	12.50	12.50	*38.00*	46.00
Philadelphia	19.00	19.00	21.00	40.00	50.00
Pittsburgh (del.)	16.00	16.00	16.00	.....	.....
Cleveland	14@16	14@16	16.00	.....	.....

*For paving blocks 3½x8½x3 and 3½x8½x4 respectively. †Imported.

HOLLOW TILE—Price per block in carload lots to contractor for hollow building tile.

	New York: Apr. 2 on Trucks*†	One Year Ago	Chicago	Philadelphia	St. Louis	San Francisco†	Perth Amboy N. J., Factory*
4x12x12	$0.1162	$0.1179	$0.06	$0.1325	$0.08	$0.108	.....
6x12x12	.1743	.1769	.0825		.108	.156	.....
8x12x12	.2179	.2211	.1125	.25	.150	.244	.....
10x12x12	.....	.....	.14	.....	.180	.....	$0.252
12x12x12	.....	.....	.18	.....	.215	.....	.312

*5 per cent off for cash. †Partition tile.

	4x12x12	8x12x12	12x12x12
Boston	*$0.095*	*$0.19*	
Minneapolis (f.o.b. cars)	.0636	*.106*	*$0.189*
Minneapolis (delivered)	.07	*.116*	*.205*
Cincinnati	.07485	.13745	.....
Kansas City	.085	.145	.....
Denver	.085	.155	.188
Seattle (delivered)	.11	.20	.30
Los Angeles	.085	.172	.....
New Orleans	.13	.....	.30
Detroit (delivered)	*.0775*	.1743	.....
Montreal	.12	.225	.30
Baltimore	.125	.27	.....
Atlanta	.0808	.1516	.....
Dallas	.0941	.1824	.265
Birmingham	.11	.1824	.22
Pittsburgh (delivered)	.068	.128	.179
Cleveland	.064	.149	.....

STRUCTURAL MATERIAL—Following are base prices f.o.b. mill, Pittsburgh and Birmingham, together with quotations per 100 lb. from warehouses at place named:

	Pittsburgh Mill	Birmingham	Warehouse: New York	Dallas	St. Louis	Chicago	San Francisco
Beams, 3 to 15 in.	$2.00@*2.10*	$2.05	$3.34	$4.15	$3.25	$3.10	$3.30
Channels, 3 to 15 in.	2.00@*2.10*	2.10	3.34	4.15	3.25	3.10	3.30
Angles, 3 to 16 in., ¼ in. thick	2.00@*2.10*	2.10	3.34	4.15	3.25	3.10	3.30
Tees, 3 in. and larger	2.00@*2.10*	2.10	3.34	4.15	3.35	3.10	3.30
Plates, ¼ in. thick and heavier	2.00@*2.10*	2.00	3.34	4.15	3.25	3.10	3.30

RIVETS—The following quotations are per 100 lb.:.

STRUCTURAL

	Pittsburgh Mill	New York: Apr. 2	New York: One Yr. Ago	Warehouse: Chicago	St. Louis	San Francisco	Dallas
¾ in.	$2.50@$2.60	$4.50	$4.40	$3.50	$3.65	$5.00	$4.75
CONE HEAD BOILER							
½ in.	$2.85@$2.90	$4.60	$4.50	*$3.70*	$3.65	$5.20	$5.00
⅝ and ¾	3.00@3.05	4.75	4.66	*3.75*	4.20@4.45	5.35	5.15
⅞ and 1	3.15@3.30	5.00	4.90	*4.00*	4.60	5.60	5.50

NAILS—The following quotations are per keg from warehouse:

	Pittsburgh Mill	Birmingham	Chicago	San Francisco	Dallas	St. Louis	Montreal
Wire	$2.85@2.95	$2.85	$3.25	$4.00	*$4.28*	$3.33	4.95
Cut	2.90	2.90	.....	5.25	5.00	3.58	5.00

SHIP SPIKES—Current prices per 100 lb.:

In.	San Francisco: Galv.	San Francisco: Black	Seattle Black
½	$8.00	$6.00	$7.75
⅝	7.30	5.30	5.40
¾	7.15	5.15	5.50

Pittsburgh base in lots of 200 kegs or more, $3.25.

PREPARED ROOFINGS—Slate-surfaced roofing (red and green) in rolls of 108 sq.ft. costs $2.86 per roll to consumers in less than carload lots f.o.b. Philadelphia.

Single shingles, red and green slate finish, cost $7.56 per square (sufficient to cover 100 sq.ft.) in less than carload lots, f.o.b. Philadelphia. Strip shingles (4 in 1) f.o.b. Philadelphia, l.c.l., $6.35 per square.

ROOFING MATERIALS—Prices f.o.b. New York, to consumers in less than carload lots:

Tar felt (14 lb. per square of 100 sq.ft.) per ton	$87.75
Tar pitch (in 400-lb. bbl.), per 100 lb.	2.03
Asphalt roofing (in barrels), per ton, f.o.b. plant*	41.51
Asphalt felt (light), per ton, f.o.b. plant*	95.00
Asphalt felt (heavy), per ton, f.o.b. plant*	95.00

* Delivered in Metropolitan Dist., $2.00 additional.

WINDOW GLASS—United inches, 25, bracket size 6x8 to 10x15, single thickness "AA," 82 per cent; "A," 86 per cent; "B," 88 per cent. Double thickness "AA," 82 per cent; "A," 85 per cent; "B," 88 per cent discount from jobbers list at New York warehouses.

SHEETS—Quotations are per 100 lb. in various cities from warehouse also the base quotations from mill:

Blue Annealed	Pittsburgh Large Mill Lots	St. Louis	Chicago	San Francisco	New York
No. 10	$2.70	$3.90	$3.80	$4.20	$3.89
No. 12	2.80	3.95	3.85	4.25	3.94
No. 16	2.90	4.00	3.95	4.30	3.99
No. 16	3.10	4.10	4.15	4.40	4.09
Black					
*Nos. 18 and 20	*3.35@3.45*	4.60	4.30	5.05	4.55
*Nos. 22 and 24	*3.40@3.50*	4.65	4.35	5.10	4.60
*No. 26	*3.45@3.55*	4.70	4.40	5.15	4.65
*No. 28	*3.50@3.60*	4.80	4.50	5.25	4.75
Galvanized					
No. 10 and 11	*3.65@3.75*	4.80	4.50	5.75	4.75
No. 12 to 14	*3.75@3.85*	4.90	4.60	5.35	4.85
No. 16	*3.90@4.00*			5.50	5.00
Nos. 17 to 21	*4.05@4.15*	5.20	4.90	5.65	5.15
Nos. 22 to 24	*4.20@4.30*	5.35	5.05	5.80	5.30
*Nos. 25 and 26	*4.35@4.45*	5.50	5.20	5.95	5.45
*No. 28	*4.65@4.75*	5.60	5.50	6.25	5.75

* For painted corrugated sheets add 30c. per 1,000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages: for galvanized corrugated sheets add 15c., all gages.

LINSEED OIL—These prices are per gallon:

	New York: Apr. 2	New York: One Year Ago	Chicago: Apr. 2	Chicago: One Year Ago
Raw in barrels (5 bbl. lots)	*$1.14*	$0.95	$1.25	$0.94

E. N.-R. Prices of Construction Materials

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound, f.o.b. New York:

	Dry		In Oil	
	Apr. 2	1 Yr. Ago	Apr. 2	1 Yr. Ago
Red	$16.25	$15.00	$17.75	$16.50
White	16.25	15.00	16.25	15.00

Lumber

Prices wholesale, per M. ft. b.m., to dealers in carload lots, f.o.b.

San Francisco—Prices of rough Douglas fir No. 1 common, in carload lots to dealers at yards. To contractors, $2 per M. ft. additional.

	6-8 and 12 Ft.	10-16-18 and 20 Ft.	22 and 24 Ft.	25 to 32 Ft.
3x3 and 4	$26.00	$27.00	$28.00	$31.00
3x6 and 8	26.00	27.00	28.00	31.00
4x4-6 and 8	26.00	27.00	28.00	31.00
3x10 and 12	26.00	27.00	28.00	31.00
3x14	30.00	30.00	32.00	34.00
4x10 and 12	26.00	27.00	28.00	31.00
4x14	30.00	30.00	32.00	34.00

	24 Ft. and Under	25 to 32 Ft.	33 to 40 Ft.
6x10	$28.00	$30.00	$32.00
6x14	33.00	36.00	38.00
8x10	28.00	30.00	32.00
8x14	33.00	36.00	38.00

New York and Chicago—Wholesale prices to dealers of long leaf yellow pine.

	New York*		Chicago	
	20 Ft. and Under	22-24 Ft.	20 Ft. and Under	22-24 Ft.
3x4 to 8x8	$48.00	$49.00	.....	.....
3x10 to 10x10	52.00	53.00	.....	.....
3x12 to 12x12	56.00	57.00	.....	.....
3x14 to 14x14	65.00	66.00	.....	.....
3x16 to 16x16	70.00	71.00	.....	.....
3x18 to 18x18	.....	.....	.....	.....
4x20 to 20x20	.....	.....	.....	.....

* Wholesale price to dealers; to contractors, delivered from lighters or cars to job, $5 additional. Short leaf pine costs $3 per M. less.

Over 24 ft.—Add $1 for each additional 2 ft. in length up to 30 ft. for sizes 12x12 and under; for sizes over 12x12 add $2; for merchantable add $2 to sizes 10x10 and under.

Other Cities

	8x8-In. x 20 Ft. and Under				12x12-In. 20 Ft. and Under	
	P.	Fir*	Hemlock	Spruce	P.	Fir*
Boston	$52.00	$48.00†	$50.00	$50.00	$62.00	$58.00†
Seattle	.....	29.50	.....	.....	.....	25.00
New Orleans	42.00	.....	.....	.....	32.00	.....
Baltimore	32.50	49.25	53.00	60.00	38.00	49.75
Cincinnati	37.00	73.00	73.00	85.00	48.00	77.00
Montreal	50.00	58.00	.....	.....	60.00	65.00
Los Angeles	.....	37.00	.....	.....	.....	38.00
Denver	.....	33.75	33.75	33.75	.....	34.75
Minneapolis	41.00	39.75	39.00	.....	43.50	39.75
Atlanta	32.00	.....	.....	.....	35.00	.....
Dallas	52.25	.....	.....	.....	56.00	.....
Kansas City	42.00	40.75	.....	.....	53.60	41.75
Birmingham	32.00	.....	.....	.....	34.00	.....
Philadelphia	60.00	32.00	39.00	42.00	68.50	32.00
Detroit	47.75	52.75	.....	.....	57.75	52.75
St. Louis	40.00	.....	.....	.....	48.00	.....

	1-In. Rough, 10 In. x 16 Ft. and Under			2-In. T. and Gr. 10 In. x 16 Ft.	
	P.	Fir*	Hemlock	P.	Fir*
Boston	$46.00	$42.00†	$44.00	$50.00	$48.00†
Seattle	.....	25.00	.....	.....	29.00
New Orleans	80.00	.....	.....	40.00	.....
Baltimore	55.00	44.00	44.00	34.00	50.00
Cincinnati	70.00	79.00	75.00	38.00	85.00
Montreal	56.00	50.00	45.00	45.00	45.00
Los Angeles	.....	32.00	.....	.....	81.00
Denver	.....	34.75	34.75	.....	32.25
Minneapolis	43.00	37.75	35.50	37.00	35.25
Atlanta	20.00	.....	.....	30.00	.....
Dallas	52.25	.....	.....	55.73	.....
Kansas City	73.25	66.75	.....	77.00	70.25
Birmingham	19.00	.....	.....	.....	.....
Philadelphia	32.00	31.00	38.00	62.00	32.00
Detroit	37.75	39.00	.....	48.00	39.75
St. Louis	42.50	.....	.....	31.00	.....

Birmingham—Quotes carload lots, f.o.b. sidings; $4.00 additional per M. ft. to contractors.
Boston and Cincinnati—Prices to contractors in carload lots, f.o.b.
Denver—Quotes dealers price to contractors on large projects.
St. Louis—Wholesale price to contractors, f.o.b. cars, $2 per M.ft. additional.
Seattle—Price to contractors, delivered.
Dallas—Wholesale to contractors, $10 per M.ft. additional.
*Douglas fir. †Prime.

PILES—Prices per lineal foot, pine piles with bark on, f.o.b. New York.

Diameters	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.14½	$0.18½
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.19	.23½
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.21½	.25½
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.25½	.34
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.27½	.36½
14 in.—2 ft. from butt	5 in.	80 to 89 ft.	.35	.41

Miscellaneous

STEEL SHEETPILING—The following price is base per 100 lb. f.o.b. Pittsburgh, with a comparison of a month and a year ago:

Apr. 2	One Month Ago	One Year Ago
$2.15@2.25	$2.15@2.25	$2.65

WIRE ROPE—Discounts from list price on regular grades of bright and galvanized are as follows:

	Eastern Territory New York and East of Missouri River
Plow steel round strand rope	35%
Special steel round strand rope	30%
Cast steel round strand rope	20%
Round strand iron and iron tiller	5%
Galvanized steel rigging and guy rope	7½%
Galvanized iron rigging and guy rope	+12½%

California, Oregon, Nevada and Washington: Discount 5 points less than discount for Eastern territory.
Wyoming, New Mexico and Colorado: Discount 5 points less than discount for Eastern territory.
Arizona: Discount 10 points less than discount for Eastern territory.
Montana, Idaho and Utah: Discount 10 points less than discount for Eastern territory.
North Dakota, Nebraska, Kansas, Oklahoma and Texas: Discount 5 points less than discount for Eastern territory.

MANILA ROPE—For rope smaller than ¾-in. the price is ½ to 2c. extra; while for quantities amounting to less than 600 ft., there is an extra charge of 1c. The number of feet per pound for the various sizes is as follows: ½-in., 8 ft.; ⅝-in., 6; ¾-in., 4½; 1-in., 3½; 1¼-in., 2 ft. 10 in.; 1½-in., 2 ft. 4 in. Following is price per pound for ½-in. and larger, in 1200-ft. coils:

Boston	$0.18@.22	New Orleans	$0.23½
New York	.27	Los Angeles	.19
Chicago	.21½	Seattle	.17
Minneapolis	.28½	St. Louis	.26½
San Francisco	.26	Montreal	.16
Atlanta	.27	Detroit	.19
Denver	.30	Baltimore	.18
Cincinnati	.21	Kansas City	.20
Dallas	.28	Birmingham	.19@.21
Philadelphia	.185		

EXPLOSIVES—Price per pound of dynamite in small lots:

	Gelatin 40%	Gelatin 60%
New York	$0.27	$0.295
Boston	.225	.25
Kansas City	.2125	.2325
Seattle	.165	.19
Chicago	.1525	.1775
Minneapolis	.1917	.2123
St. Louis	.22	.245
Denver	.2025	.2275
Dallas	.225	.302
Los Angeles	.1875	.2125
Atlanta	.23	.255
Baltimore	.22	.23
Cincinnati	.22	.245
Montreal	.195	.235
Birmingham	.23	.255
New Orleans	.233	.26
San Francisco	.1625	.1925
Philadelphia	.215	.24

CHEMICALS—Water and sewage treatment chemicals, spot shipments in carload lots, f.o.b. New York:

Sulphate of aluminum, in bags, per 100 lb	$1.40@1.45
Sulphate of copper, in bbl., per 100 lb	4.65@4.85
Soda ash, 58%, in bags, per 100 lb	1.85
Chlorine, liquid tanks, per lb. (f.o.b. works)	.04½
Hypochlorite of lime (bleaching powder) in drums, per 100 lb	2.00@2.10

FREIGHT RATES—On finished steel products in the Pittsburgh district, including plates, structural shapes, merchant steel, bars, pipe fittings, plain and galvanized wire nails, rivets, spikes, bolts, flat sheets (except planished), chains, etc., the following freight rates are effective in cents per 100 lb., in carloads of 36,000 lb.:

Baltimore	$0.31	Detroit	$0.29
Birmingham	.58	Kansas City	.735
Boston	.365	New Orleans	.67
Buffalo	.265	New York	.34
Chicago	.34	Pacific Coast (all rail)	1.15*
Cincinnati	.29	Philadelphia	.32
Cleveland	.19	St. Louis	.43
Denver	1.15*	St. Paul	.60

* Minimum carload, 50,000 lb., structural steel only; 80,000 lb., for other iron or steel products.